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Authenticity and technology: constructing meaning from an e-mail activity

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Authenticity and technology:

Constructing meaning from an e-mail activity

by

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ABSTRACT

This study investigated 28 preservice teachers' involvement in a ten-week long e-mail project linking them with elementary students in a mathematical problem solving activity. The preservice teachers sent mathematical problems each week to their student groups via e-mail. The elementary students solved the problems and responded with their solution and an explanation of their process. Of the college students, three preservice teachers with high levels of mathematics anxiety and three with low levels of anxiety were selected to be examined in case studies. Interviews with the case study participants, as well as data collected from all of the class members, provided insight into their perceptions of the e-mail activity.

Results showed that the overall quality of the problems sent by the preservice teachers to their student groups increased as they learned about the skills of their elementary partners. They were very concerned about choosing problems at the appropriate difficulty level for their students, and cited good explanations of the problem solving process by the elementary students as being a key to their understanding. When poor explanations were provided by the elementary students, the preservice teachers' impressions of the e-mail activity were less favorable overall.

The preservice teachers rated a set of problems more consistently with the participating teachers at the end of the e-mail activity than they did at the beginning, showing their understanding of what was appropriate for their student groups. However, the problems selected by the preservice teachers were not completely consistent with their beliefs of what good problems should entail. Mathematical anxiety levels had some influence on these inconsistencies, but anxiety levels had a smaller effect on participation than was anticipated.

Myers' (1993) criteria for determining the authenticity of an activity demonstrated the potential of electronic links to make a favorable impact in teacher preparation programs. For this reason, benefits and limitations to using telecommunications in preservice teacher preparation programs were explored.

CHAPTER 1. INTRODUCTION

The National Council of Teachers of Mathematics (NCTM) Standards, developed to provide teachers with guidelines for the types of mathematical experiences their students should have, are based on a constructivist philosophy of teaching and learning. The Standards suggest that mathematical skills are developed by constructing knowledge in various ways, including through the use of manipulatives, small group work, and writing activities. Unfortunately, the approach advocated by the NCTM is one in which preservice teachers have little background knowledge; their own teachers were more likely to follow behaviorist instructional principles rather than constructivist approaches in their mathematics curricula (NCTM, 1991; Schifter & Simon, 1992). As a result, preservice teachers need experiences to help them understand the changing focus of mathematics and mathematical instruction. They need first-hand involvement in activities to help them understand how to teach the subject using a constructive approach. If there is merit in constructivist principles, then a constructivist approach in mathematics teaching methods courses should not only prepare future teachers to use these principles in their teaching, but also help the preservice teachers construct meaning about mathematics and the way children learn mathematical concepts.

Part of the success of the constructivist approach is the creation of authentic experiences for learners. Authentic activities are those perceived as real or genuine by the learner, those that challenge and empower learners to take risks, and those making some difference in the lives of the learners (Myers, 1993). Activities designed to help teach preservice teachers how to teach mathematical problem solving skills to children will be most effective if they are perceived as authentic rather than contrived.

Many preservice teachers have few opportunities to observe children in a constructivist-based mathematical environment prior to their enrollment in mathematics teaching methods courses. For this reason, field experiences may enable the preservice teachers to gain some exposure to a classroom mathematics atmosphere. These experiences allow preservice teachers to search for meaning and understanding in actual school environments. Since not all practicing teachers regard problem solving as an important aspect of their curriculum, the field experience alone may not adequately address all of the needs of the preservice teachers

(Rising, 1988). In addition, it is not always practical or possible to provide quality school experiences to help prepare future teachers in all aspects of teaching and learning. Alternatives need to be explored to enhance their school placements and college coursework.

Another consideration in the preparation of preservice teachers to teach mathematics is the preservice teachers' mathematical anxiety levels. It is well-documented that elementary education majors often exhibit high levels of mathematical anxiety (Brownell, Jadallah, & Brownell, 1993; Conrad & Tracy, 1992; Kelly & Tomhave, 1985). Research indicates that anxiety levels toward mathematics influence what these teachers choose to teach in their mathematics curriculums as well as their whole approach to teaching the subject (Brophy, 1991; Conrad & Tracy, 1992; Grouws, 1985; Silver, 1985). Teachers exhibiting high levels of anxiety toward mathematics tend to implement more drill and practice exercises and follow a more behavioral teaching style than teachers who demonstrate less mathematical anxiety. Teachers with high levels of mathematical anxiety are less likely to follow the guidelines advocated by the NCTM. Thus, if teaching methods courses can help to decrease anxiety levels among future teachers, or at least create situations where preservice teachers with high anxiety levels feel more relaxed, it is possible that their teaching approaches might be more consistent with what the NCTM suggests.

Telecommunications has been one of the fastest growing areas of computerized technologies over the past few years, and the educational community has begun to explore the opportunities that this technology brings to the classroom (Clark, 1988; D'Souza, 1992). Teachers actively seek ways to integrate telecommunications into their curriculum once they have the capability in their classrooms to do so, often without a solid theoretical foundation for their activities (Maddux, 1991). The development of telecommunications applications has outpaced the research to determine the effectiveness of these activities on learners, especially as used in the preparation of teachers (Harasim, 1990).

Most of the available literature describing the use of telecommunications by preservice teachers documents links between student teachers and their supervising and cooperating teachers or it documents the interactions between preservice teachers and their professors (Durham & Sunal, 1991; Russett, 1994; Thompson & Hamilton, 1991). The possible impact of using telecommunications to link preservice teachers with

elementary or secondary students has received little attention (Russett, 1994). It is considered important to teach teacher candidates how to teach with technology, but rarely are implications of using the technology to assist them in their own learning examined (Office of Technology Assessment, 1995). The potential of telecommunications is included in this oversight.

The use of technology should be critically scrutinized in all educational situations (Maddux, 1991). Because technology is still a relatively novel item in teacher preparation programs, it has the potential to be used to add glitz and glitter to courses instead of to add instructional value; technology often gets used merely because it is available and faculty are expected to use it. This is certainly true for telecommunications activities. There is a lot of appeal to using telecommunications technologies in the curriculum, but there is danger in letting the technology drive the curriculum. It is important to evaluate how the technology can be used to enhance the teacher education curriculum so that new teachers are better prepared for their profession.

The use of telecommunications in the preservice teacher preparation curriculum may be a viable option to help prepare future teachers, if used to link preservice teachers to elementary or secondary children. It is possible that the physical distance separating preservice teachers from the elementary students in telecommunications-based activities eliminates or decreases the impact of mathematics anxiety. If so, then the use of telecommunications in preservice teacher preparation programs needs to be explored further since it could have monumental implications on the quality of mathematics teaching. To date, however, little research has been undertaken to examine the effects of establishing electronic links between these populations (Russett, 1994). As a result, telecommunications-based activities have not been explored sufficiently to determine whether the technology can be used to create authentic learning environments that help prepare future teachers.

To examine the potential of telecommunications activities in teacher preparation programs, an electronic mail activity was constructed to link elementary students with preservice teachers in a mathematical problem solving environment. The preservice teachers communicated with elementary students over a ten week period. The primary focus of the communications was mathematical problems that the elementary students solved and described. The involvement of the preservice teachers in this activity was the focus of the research project.

Chapter one is organized to provide basic information about several of the key elements of this study. This chapter has five sections: 1) an explanation of the study's research problem, 2) a description of the purpose of the study, 3) the research questions, 4) a definition of terms, and 5) a chapter summary.

Statement of the Problem

In 1989, the NCTM introduced an approach to teaching and learning mathematics that was different from what most teachers and college students preparing to be teachers experienced in their own mathematics instruction. Despite what I was teaching in the mathematics teaching methods course, many of the preservice teachers in my class still thought of mathematics as predominantly drill and practice exercises. They had a difficult time understanding how elementary children could construct meaning of mathematics concepts. They also had a difficult time seeing themselves as constructivist-based teachers. A field experience and lots of work using manipulatives helped to bridge the gap that existed between their prior experiences and what the NCTM suggested. However, I felt there was still something missing. The preservice teachers were still uncomfortable with the constructivist approach to teaching, especially with respect to mathematics. To address this deficiency, the telecommunications activity described in this study was developed.

It is possible that electronic links between preservice teachers and elementary students may yield great benefits in teacher preparation programs, specifically in the area of mathematics. Because of the physical distance between the preservice teachers and the elementary students in telecommunications activities, the anxiety that some of the preservice teachers experience in face to face mathematical situations with elementary students may be minimized. In addition, it is possible that telecommunications-based activities may help preservice teachers formulate an understanding of the childrens' development of problem solving skills in a way that is not addressed using other techniques. However, since there is little or no face-to-face contact with people in e-mail activities, it was unclear whether the e-mail activity would be considered an authentic experience by the preservice teachers.

Purpose of the Study

The overall purpose of the study was to learn about the effectiveness of an e-mail activity in terms of preparing future teachers to teach mathematical problem solving skills. The study examined the interactions that preservice teachers had with elementary students when they were electronically linked in a mathematical problem solving activity. It also looked at the reactions of the preservice teachers toward their participation in the activity. The study focused on determining if a telecommunications-based activity was an authentic learning experience for the preservice teachers, and in gaining an understanding of whether telecommunications could be used to help better prepare preservice teachers to teach mathematical problem solving to elementary children. The study also examined whether anxiety toward mathematics influenced the interactions of the preservice teachers with the elementary students.

Research Questions

A qualitative approach was undertaken in this study to provide a detailed picture of the preservice teachers' involvement in the activity. This broad emphasis was addressed through a series of research questions:

1. How do the preservice teachers choose to involve themselves in the e-mail activity?
2. What is the influence of mathematical anxiety on the preservice teachers' involvement in the e-mail activity?
3. What is the degree of perception of the e-mail activity as an authentic experience for the preservice teachers?
4. What can be learned about how to effectively construct meaningful and beneficial e-mail experiences for preservice teachers?

The study was designed to examine the effectiveness of a telecommunications-based activity in the preparation of future teachers.

Definition of Terms

Problem

In this study, the reference to problems specifically pertained to non-routine mathematical problems. Such problems are "tasks where the solution or goal is not immediately attainable and there is no obvious algorithm" (McLeod, 1988, p. 135). Problems are not merely computations put to words. Because learners are at various levels of understanding regarding different ideas and algorithms, what may be a problem for one learner may not be a problem for another child. One of the purposes for developing the e-mail activity was to provide the preservice teachers with some experience trying to decide what may or may not be a problem for different groups of learners.

Problem solving

Problem solving is not a specific topic but rather, "a process that should permeate the entire program and provide context in which concepts and skills can be learned" (NCTM, 1989, p. 23). As such, problem solving consists of both the mental and behavioral activities that are involved as a solution to a problem is formulated. It should be the primary area of emphasis in the mathematics curriculum according to the National Council of Teacher of Mathematics (1989). Because it is the focal point of the NCTM Standards, preservice teachers need to understand what problem solving encompasses. They also need to understand how they can help children develop skills in this area.

Because problem solving is an entire process, forcing the preservice teachers to select one problem each week to send to their elementary student groups may not have been entirely consistent with the NCTM Standards. The NCTM's definition of problem solving focuses on children exploring relationships between items and developing a conceptual understanding that may not result from simply solving one non-routine item per week. However, even non-routine word problems begin to address the NCTM Standards by forcing students to communicate mathematically and to think about how to approach a problem.

Appropriate problems

For the purposes of this study, an appropriate problem met three criteria: 1) It was a mathematical question that the elementary student groups were able to solve, given their mathematical and problem solving skills, 2) it was an item that the elementary students could address successfully through the telecommunications medium, and 3) it was consistent with the NCTM's principles of effective problems, meaning that problems should be more than simply computations put to words; they should involve real contexts familiar to children, they should involve the collection of real data, and when possible, they should be open-ended situations or those with the possibility of multiple solutions.

Problematic interaction

A problematic interaction in the study was a message selected by the preservice teachers during the sixth week of the e-mail activity that was troubling to them in some way. These interactions were electronically forwarded for analysis to me, along with an explanation of why they were selected. These choices helped to provide an understanding of what the preservice teachers learned from the e-mail activity and their perceptions of their participation. Because authenticity deals with the learners' perceptions of activities, the focus was on the preservice teachers' views of what may be problematic about their involvement rather than on the perceptions others held regarding what was problematic.

Positive interaction

A positive interaction was a message selected by the preservice teachers that provided them with a sense of satisfaction regarding their involvement. As with the problematic interaction, these messages were electronically forwarded to me, along with an explanation of their selections.

Mathematics anxiety

For the purpose of this study, Richardson & Suinn's (1972) definition of mathematical anxiety was used. They described mathematical anxiety as, "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (p. 552). Other definitions stressed the panic, helplessness, paralysis and mental

disorganization that some people experience when required to solve a mathematical problem (Hunt, 1985). Richardson & Suinn's definition was selected because it extended outside of classroom walls to include life situations. In addition, their instrument was designed to measure anxiety based on this definition.

Authenticity

Although there are many different definitions of authenticity, the criteria developed by Myers (1993) were used in the study: (1) The activity is perceived as real or genuine by the learner; (2) The activity challenges, inspires, and empowers learners to take risks and exceed personal limitations; and (3) The activity makes some difference in the life of the learner. This definition was selected because it provided specific criteria that could be measured with respect to the preservice teachers' involvement in the e-mail activity.

Summary

Telecommunications has the potential to be an important tool in the preparation of future teachers because of its capacity to link preservice teachers with the real children that they are preparing to someday teach. As a result, the use of telecommunications in undergraduate coursework may be a tool used to create authentic experiences for preservice teachers. On the other hand, electronic communications also has the potential to be simply a neat "toy" to use in the curriculum with no real educational value. It is important to examine the use of this technology in the undergraduate education curriculum to determine the extent to which it contributes to the growth of the preservice teachers.

The literature contains many descriptions of activities involving the use of telecommunications, but few studies examine the effects on the participants, especially when preservice teachers are linked with elementary or secondary students. The exploration of how the use of telecommunications can facilitate a constructivist environment for the preservice teachers has also been largely unexamined. Ball suggested that the influence of different experiences on preservice teachers' knowledge about and orientations toward mathematics and math teaching and learning need to be examined to determine how teacher education programs can become more effective (1988). This study attempted to address this need.

CHAPTER II. LITERATURE REVIEW

This chapter addresses literature dealing with several factors that influenced this study. It is organized into six sections: 1) the NCTM Standards; 2) constructivism; 3) teacher preparation in mathematics; 4) anxiety toward mathematics; 5) the Internet and telecommunications; and 6) a summary of the chapter.

The National Council of Teachers of Mathematics

The NCTM Standards were an important influence on this study. The NCTM Standards outline the content of the K-12 mathematics curriculum based on the perceived needs of the society (NCTM, 1989). The NCTM also provided direction for teachers to help address its suggested content (1991). For teachers to integrate these Standards and approaches into their curriculum, they need to be provided with the training to help them do so. This is true for both practicing teachers and preservice teachers. Since problem solving is one of the staples of the NCTM's curriculum standards, preservice teacher preparation programs must prepare teachers to help children develop this skill.

Standards are written for the K-4, 5-8, and 9-12 grade levels, with different areas of focus defined at each grade range. There are four common themes across each of these levels: Mathematics as Communication, Mathematics as Connections, Mathematics as Reasoning, and Mathematics as Problem Solving. If the Standards are to be addressed in K-12 curriculum, then teachers must understand how to address each of these focus areas with their students.

Mathematical Problem Solving

In the past, children often learned mathematical algorithms without understanding the underlying principles behind why those procedures worked. Mathematics became synonymous with computations as a result of these practices. With the availability of tools such as calculators and computers, the need for proficiency with calculations became less of a necessity. Instead, mathematical problem solving became a more valued skill, and the NCTM Standards reflect that change. The NCTM Standards emphasize processes and

strategies rather than rote memorization of procedures. These processes and strategies include such skills as, "the ability to use, explore, conjecture, and reason logically, as well as the ability to use a variety of mathematical methods effectively to solve non-routine problems" (NCTM, 1989, p. 5). The Standards also include the students' development of the self-confidence and disposition to be able to perform these tasks.

Although problem solving is just one of the themes included in the Standards, it is heavily emphasized by the NCTM. This organization believes that problem solving should not be a distinct topic, but "a process that permeates the entire program and provides the context in which concepts and skills can be learned" (NCTM, 1989, p. 23). This may not happen if teachers progress through textbook series without using any supplemental materials or activities. Problems typically found at the end of textbook sections often only utilize one specific skill, and can be refined to a mechanical process where little thought is involved in formulating a solution. Students often have difficulty understanding when to apply these same algorithms in situations where a choice needs to be made about how to progress. Also, typical mathematics series provide few opportunities for students to challenge ideas, propose and solve interesting problems, or simply spend time thinking before a response is elicited (Silver, 1985). Most textbooks, despite the NCTM Standards, do not foster an active problem solving approach. Therefore, teacher preparation programs need to consider ways to help future teachers address problem solving in their mathematics curriculum.

Communication

Although problem solving is one of the major areas of focus for the NCTM, the ability of children to communicate their mathematical ideas, processes, and understanding is another element of the Standards. Since a problem solving environment is one where students explore mathematical ideas in a variety of ways, it is important for students to "construct links between their notions and the abstract language and symbolism of mathematics" (NCTM, 1989, p. 26). Oral and written communication are pieces of this exploration as communication allows learners a means of justifying their discoveries. Through talking, writing, and showing, students demonstrate their understanding of concepts rather than simply performing memorized tasks. The teacher and the textbook are no longer the sole sources of validity and truth; rather, the students construct and justify their own meaning and understanding of ideas through communication (Simon, 1994).

The goal of the communications standard is for children to develop power through learning the signs, symbols, and terminology of mathematics. "This is best accomplished in problem situations in which students have an opportunity to read, write, and discuss ideas where the use of the language of mathematics becomes natural. As students communicate their ideas, they learn to clarity, refine, and consolidate their thinking" (NCTM, 1989, p. 6). Writing about mathematics, and in particular, writing about how a problem was solved, "helps students clarify their thinking and develop deeper understanding" (NCTM, 1989, p. 26).

Research indicates that successful programs designed to enhance problem solving skills have two common features: they get students to adopt an active stance toward problem solving, and the problem solving setting is one that facilitates growth in this area (Kilpatrick, 1985). Writing about the processes used in solving problems may address both of these features. Gage described his views of how writing could help cognitive growth (1989):

> Writing is thinking made tangible, thinking that can be examined because it is on the page and not in the head invisibly floating around. Writing is thinking that can be stopped and tinkered with. It is a way of holding thought still enough to examine its structure, its flaws. The road to clearer understanding of one's thoughts is traveled on paper. It is through an attempt to find words for ourselves in which to express related ideas that we often discover what we think. (Cited in Harasim, 1990, p. 49)

Gage was not speaking specifically about writing through the use of e-mail in this quote. However, Harasim suggested that on-line communication may improve the writing process. Harasim said, "Reading and writing online can be conceptualized as unique ways of thinking about and exploring a topic en route to building knowledge" (p. 49). The use of telecommunications in the mathematics curriculum, therefore, may help elementary students to strengthen their mathematical skills since the medium fosters active communication and growth of ideas.

In addition, electronic mail interactions provide the opportunity for an audience. Fox suggested that in order for writing to be effective, an audience needs to be involved (1993). She made three observations about successful student writing: 1) Students care more about writing if it is something they care about doing, 2) the students should have responses from real people and not just the teacher, and 3) situations where students own the investment of their writing are ideal. Telecommunications activities have the potential to address all three of these items. Telecommunications environments allow the students to have an audience made up of real people

who are interested in the students' thoughts. They receive feedback from another person who is not their classroom teacher. When writing to someone via e-mail, the students write for a purpose that goes beyond satisfying a requirement that the teacher makes--the medium is a powerful motivator because of the connections that can be established.

The communication that occurs through e-mail activities may help children develop problem solving skills, provided activities are constructed in a way to do so. Two of the teachers who participated in the e-mail activity wrote about their students' involvement in the project and how the activity helped the students problem solving skill development (Brennan & Yantosh, 1996). They said,

> The Internet provided an exciting way to talk and write about mathematics. The focused give and take with someone outside the classroom context engaged students in a new and meaningful way, motivating them to go that extra distance, and to struggle with different methods of conceptualizing the problem until they achieved success. (p. 40)

These teachers felt that the audience provided in the e-mail activity was empowering to the students in a way that encouraged them to talk and write about mathematics. They felt that the students might have tried harder to solve the problems than they may have in a regular classroom situation.

In the e-mail activity described in this study, elementary students responded to non-routine mathematics problems sent to them by preservice teachers who were preparing to become elementary teachers. The elementary students were asked to write about the process that they used to solve their weekly problem. For some of the elementary students, especially those at the lower grade levels and those with little experience describing their thinking, writing about their problem solving process was a difficult task. However, the task not only allowed the elementary students to grow in their mathematical and problem solving development, it also allowed the preservice teachers to construct an understanding of how the elementary children solved problems. If teachers can attend to their students' mathematical communication, they will be provided with an information base that gives them insight into what the students understand (NCTM, 1989). Because of the structure of e-mail, it might be a medium to facilitate this understanding. Clearly, the two participating teachers who wrote about their students' experiences with the e-mail activity felt that such a project benefited their elementary students (Brennan & Yantosh, 1996). The possible benefits for the preservice teachers were examined in this study.

Constructivism

The approach to teaching mathematics advocated by the NCTM is based on constructivism. Constructivism is a theory of learning that may better address the needs of today's learners than past instructional practices. With the amount of rapidly changing information that currently infiltrates society, it is important for learners to develop a conceptual understanding of ideas (Duffy & Jonassen, 1992; Stoddart, Connell, Stofflett & Peck, 1993). A constructivist approach may help foster this understanding.

Behaviorism

An overview of behaviorism is offered to help demonstrate the differences between constructivist theories and other theories of learning that were (and still are) influential in school practices. Behaviorism is one such theory. Behaviorism is based largely on the principle that learning is observable and measurable. Instruction, therefore, is geared to produce a visible change in the learner. This can be accomplished through classical conditioning, pairing stimuli with responses, or operant conditioning, the use of positive and negative reinforcement to elicit responses. In schools, teachers often use stimuli that evoke desired responses or performances from students. Reinforcement techniques are used to shape desired behaviors and distinguish unwanted behaviors. Instruction is broken down into small components and presented systematically to the learner. Behaviorist approaches are practiced in today's schools in such activities as drill and practice worksheets, behavior modification techniques, and computer-based instruction.

Behaviorist practices have dominated mathematics education, with drill and practice being a key to mathematics instruction. Reinforcement was used to encourage students to learn required processes and procedures. These practices served the needs of society for many years--and they continue to serve a need. However, there is a growing dissatisfaction with behavioral approaches in mathematics instruction. Some educators feel students learn processes without actually *understanding* what they are doing when behavioral practices are employed (Brandt, 1993; Choi & Hannafin, 1995; von Glasersfeld, 1995). The NCTM echoed this sentiment and called for a different instructional approach that may better address the mathematical skills learners need for the Information Age.

Constructivist Principles

Constructivism is based largely on the work of Jean Piaget and is formulated on the premise that learners build their own knowledge. In a constructivist environment the learner builds an "internal representation of knowledge, a personal interpretation of experience" (Bednar, Cunningham, Duffy, & Perry, 1992, p. 21). The student is the center of learning; the teacher is a facilitator who creates meaningful situations for the students to explore rather than being the provider of reinforcement or stimuli.

It is believed that schemas or cognitive structures are built by learners in an active response to sensory experiences (Saunders, 1992; Wood, 1995). Cognitive structures are activated in the process of knowledge construction as learners reflect on their actions and on the environment (Noddings, 1990; von Glasersfeld, 1995). Factors inside the mind of the learner such as prior knowledge, naïve conceptions, motivation, attention, and cognitive style influence the way they reflect on new experiences (Saunders, 1992). "Constructivism derives from a philosophical position that we as human beings have no access to an objective reality, that is, a reality independent to our way of knowing it" (Simon, 1995, p. 115). Previous knowledge, based on experiences, therefore, is what facilitates meaning and understanding (Duffy & Jonassen, 1992). Since past experiences and influences cannot be the same for any two people, the meaning created from a situation is different for each person, and there can be no "set" of behaviors or performances that can be expected from all learners. Each learner may garner something different from an activity because of their unique mental representations.

The National Council of Teachers of Mathematics endorses the constructivist approach to teaching and learning (1989, 1991). In fact, they base their curricular standards on the premise that mathematics should be conceptually rather than procedurally oriented. They believe that children should be actively involved in *doing* mathematics using a variety of physical materials and manipulatives to help them explore, justify, represent, describe, develop, and ultimately understand mathematics. The NCTM believes that children need to actively engage in problem situations in order to learn (NCTM, 1989).

Authenticity

Constructivism is rooted in the belief that coherent, meaningful, and purposeful cognitive activities are needed in order for learners to develop understanding (Choi & Hannafin, 1995; Saunders, 1992; Schifter &

Simon, 1992). These activities should be problem-based and rooted in authentic contexts. Authentic experiences are crucial to the constructivist approach.

Authenticity is based on the perception of the value of a particular activity or instructional event, existing on a continuum (Cronin, 1993; Schnitzer, 1993; Steffe & D'Ambrosio, 1995). An authentic activity is one that is perceived as real or genuine; something perceived as valuable beyond success in school (Myers, 1993). Even if an activity is a simulation of a real-life event, it is not authentic if the learner does not perceive it to be meaningful. This "real-worldness" applies to both the content and context in which it is based (Bednar, Cunningham, Duffy, & Perry, 1992).

Real-life events or activities are only pieces of authentic contexts. Myers focused on three themes to determine the authenticity of an activity (1993, p. 72):

1. The activity provides opportunities for students to achieve something that they perceive as real or genuine.
2. The activity challenges, inspires, and empowers the learner to take risks and exceed personal limitations.
3. The students are committed to having the activity make some difference in their lives.

Myers believed that an activity can be authentic only if learners own it personally; learners must make a commitment in creating value from the instruction that goes beyond a course grade. "Students must be willing to experience discomfort, failure, rejection, and, worst of all, being wrong. Learning becomes an adventure only when it challenges students to expose all that they already know for the promise of new, unimagined possibilities" (1993, p. 72).

Newmann and Wehlage offered another definition of authenticity (1993). They defined authentic activities as those meeting three criteria: students construct and produce their own knowledge, students use disciplined inquiry to construct meaning, and students aim their work at performances that have meaning beyond the school setting. Their definition of authentic learning is one that focuses on the learner's understanding of an

activity's purpose in ways where they can discover both what they know and do not know, and where they can explore opportunities that allow them to expand their knowledge (Krovetz, Casterson, McKowen & Willis, 1993).

Constructivism and preservice teachers

Engaging preservice teachers in problem situations may be an effective way to increase their understanding of how to teach mathematics and mathematical problem solving to elementary children (Schifter & Simon, 1992). "Adults, as well as children, naturally construct concepts when placed in inquiry environments or other situations that stimulate cognitive conflict and allow for exploration and individual control over learning" (Cannella & Reiff, 1994, p. 30). Placing preservice teachers in this type of environment may help them understand how children think and learn and therefore make them more aware of their role in the development of mathematical problem solving skills.

This inquiry-based exploration may be difficult to construct in a traditional college classroom. Preservice teachers' understanding of content and pedagogy is powerfully influenced by their own experiences as students, which are largely devoid of constructivist models (Stoddart, Connell, Stofflett, & Peck, 1993). Teachers have not traditionally been placed in learning situations that require inquiry and discovery; as a result, they may have difficulty not only understanding themselves as learners but also in seeing elementary students in the role of active learners (Cannella & Reiff, 1994). A constructivist approach in the methods of teaching courses can model effective teaching techniques, and may even help the preservice teachers to develop a conceptual understanding of mathematical topics that they previously had not developed (Ball, 1988). However, this type of learning environment may be frustrating for preservice teachers. They are accustomed to having absolute answers to problems and being told what they need to know, especially in mathematics. In constructivist environment they are not governed by the same rules and procedures as in more traditional environments (Raymond & Santos, 1995).

Several studies support the idea of using a constructivist approach in teacher education programs. "Themselves products of traditional mathematics education, teachers must redefine their ideas about mathematics learning and teaching" (Schifter & Simon, 1992, p. 187). The use of constructivist principles in these courses

may help them redefine what it means to learn mathematics. The NCTM suggested that it is important for teachers to truly understand the mathematics content addressed in the curriculum they teach (1991). The use of manipulatives in the teaching methods course may serve as a model for the preservice teachers to understand how they can help children develop a conceptual understanding of mathematical ideas. The use of manipulatives in teacher preparation programs may also allow the preservice teachers to understand content that they had not conceptualized in their own school experiences (Sherman, 1992). Therefore, a constructivist-based approach to teaching and learning in the mathematics methods course may address two needs.

Regardless of the exact methods used, a constructivist approach in the preparation of preservice teachers would include activities where teacher education students construct their own ideas about mathematics and how to teach this subject. Coursework including the use of manipulatives may be one inquiry-based approach to assist them in their cognitive development. It may be difficult for the preservice teachers to construct meaning about how to teach problem solving skills without direct experiences working with children in a mathematical environment, however. Bringing elementary students into the teacher preparation classroom may be one possible way to address this issue. It may also be possible to provide the preservice teachers with field experiences in constructivist-based classrooms where they could see and work with the students in the actual school environment. As positive as these opportunities may be, it may not always be possible or practical to provide these experiences for preservice teachers. Although telecommunications may not yield the same results as actual face-to-face contact with elementary students, telecommunications-based activities may still help preservice teachers construct meaning about mathematics and the development of mathematical problem solving skills in elementary children.

Teacher Preparation in Mathematics

Several national reports called for improvements in the mathematics that is taught in the nation's schools (NCTM, 1989; Mathematical Sciences Education Board National Research Council, 1991). Although there are several reasons why American students are lacking in mathematics skills, one of the possible contributors is that teachers are not adequately trained to teach mathematics to students (Garner-Gilchrist, 1993).

Leitzel suggested that the mathematical preparation of elementary school teachers is the weakest link among mathematics educators (1991). Increasing the mathematical problem solving skills of K-12 students needs to begin, then, with the preparation of teachers to adequately address this skill.

Addressing beliefs about mathematics

There is evidence that the driving force behind the teaching of mathematics may be the teacher's beliefs about what mathematics is and what it means to know mathematics (Bright & Vacc, 1994; Nicholas & Fleener, 1994/1995; Raymond & Santos, 1995). What it means to know mathematics is affected by past experiences to the extent that past experiences are more influential than the literature on learning (Isenberg & Altizer-Tuning, 1988; Stoddart, Connell, Stofflett, & Peck, 1993). According to Schifter and Simon, since teachers are products of traditional mathematics education, "they must refine their ideas about mathematics learning and teaching" in order to use the methodologies and approaches that are currently emphasized by the National Council of Teachers of Mathematics (1991, p. 187). What teachers believe about teaching and learning mathematics significantly affects the form and type of instruction they deliver (Cannella & Reiff, 1994; Clark & Peterson, 1986; Romberg & Carpenter, 1986). Fleener & Nicholas (1994/95) said that "the beliefs that preservice teachers have about mathematical learning include the ideas that elementary math is skills driven, mathematical knowledge is rule oriented, and the role of the teacher is to convey knowledge while the role of the student is to memorize" (p. 14). If teachers' beliefs are incompatible with the underlying philosophy and materials of a curriculum, full implementation of that curriculum is unlikely (Bright & Vacc, 1994). The beliefs many teachers currently have regarding mathematics are certainly inconsistent with the NCTM's position.

The NCTM Professional Standards (1991) note that, "learning to teach is a process of integration" (p. 124). This refers to the integration of theory and practice: pre-service teachers need to be able to reflect on their own learning environments as they participate in instruction and field experiences. Concrete experiences are necessary to promote this reflectiveness. These concrete experiences may deal directly with teaching methods such as the use of manipulatives to understand a concept. They may alternatively involve directly working with children. With concrete experiences, the preservice teachers "are able to independently explore their own conjectures and to extend their mathematical ideas" (p. 131). Preservice teachers develop little meaning from

teacher education faculty members who try to "transfer" what they know to their students (Simon, 1995). Instead, preservice teachers must actively engage in problem situations that are meaningful and authentic to them in order to develop an understanding of what they are expected to teach (Choi & Hannafin, 1995; NCTM, 1989; Schifter & Simon, 1992).

Learners, including people preparing to be teachers, should experience mathematics as a dynamic engagement in solving problems (NCTM, 1991). "These experiences should be designed deliberately to help teachers rethink their conceptions of what mathematics is, what a mathematics class is like, and how mathematics is learned" (p. 128). This change is not a simple one for preservice teachers to make. Ball said, "...if prospective teachers think of word problems as "problem solving"--and find them threatening besides--it may be difficult to help them move beyond an exclusive focus on computational skills in thinking about math" (1988, p. 46). She also said, however, that some of the ideas held by these future teachers may be influenced by new evidence or experiences that lead them to believe otherwise. If activities can be implemented that help the preservice teachers to develop new understandings of mathematics, then they may alter their conception of what mathematics encompasses.

The beliefs that teachers have directly influence their actions, and their actions influence their students' belief systems (Kloosterman & Stage, 1992; Lester, Garofalo, & Kroll, 1989; Raymond & Santos, 1995). Preservice teachers' beliefs should be challenged so that they may become more aware of their conceptions and how their beliefs influence their classroom experiences (Raymond & Santos, 1995). Raymond and Santos found that many of the preservice teachers who were enrolled in an activity-based mathematics teaching methods course developed a sense of themselves as doers of mathematics (1995). College courses taught in a manner consistent with the NCTM Standards may be influential in helping preservice teachers have more positive beliefs about mathematics (Madsen, 1992) as well as providing an opportunity for preservice teachers to rethink their role in mathematics education.

Field experiences

Class experiences in mathematics teaching methods courses should provide preservice teachers the opportunity to rethink what mathematics is. One possible way to do this is through effective field placements.

Although not all of the preservice teachers are placed in classrooms that support the NCTM Standards, many of them are. Discussions in the teaching methods course can encourage the preservice teachers to share their field experiences so that even those who are not placed in a constructivist classroom can get some idea of the mathematical experiences of students in those environments. Discussions are not as powerful as first-hand knowledge, but they still may help preservice teachers to challenge their belief systems.

Goodman (1986) suggested that preservice teachers' early contact experiences in schools be reflective and under instructor guidance. Early field experiences can otherwise be frustrating to the preservice teachers because they tend to focus on management concerns rather than focusing on the content area (Richards, Moore, & Gipe, 1994). These early field experiences can help the preservice teachers develop an understanding of the children they will someday teach. Sherman suggested that, "the connections students [preservice teachers] make between information provided during course lectures and discussions and implementation of those theories in the actual classroom setting allow the education student to reflect upon and build their teaching techniques with immediate feedback" (1992, p. 30). All of this is consistent with the constructivist approach.

Telecommunications and the preparation of teachers to teach mathematics

The NCTM outlined several skills that teachers must develop in order for them to provide the type of instruction summarized in the Curriculum and Evaluation Standards (NCTM 1991). The NCTM claimed that teachers must have a good knowledge *of* mathematics, they must have a knowledge *about* mathematics, they must create useful and meaningful theories of mathematics learning, they must have an understanding of the way students develop meaning of a particular mathematical concept, they must have the ability to create instruction using a constructivist approach, and they must be able to effectively interact with students by listening, questioning, monitoring, and facilitating (NCTM, 1991). These types of skills are ones that would be difficult to teach in a methods class without links to real children.

In an effort to control for the wide range of practicum placements, a common experience for all of the preservice teachers may encourage a more lively dialog in teaching methods courses. Telecommunications-based activities may possibly address this need. It is possible that the use of telecommunications is a cost effective way to increase preservice teacher contact time with students in an environment where the college instructor can

monitor and guide the preservice teachers. Although telecommunications is not mentioned outright by the NCTM as a technology that will facilitate the preparation of preservice teachers, the use of this technology has the potential for creating environments where future teachers can learn about the abilities and interests of children in a way that fosters their own construction of understanding.

In addition, it has been suggested that telecommunications can enhance the range and scope of what students learn in the classroom (Honey & Henriquez, 1993). Teacher preparation students may benefit from their participation in telecommunications-based activities as much as other audiences learn from participation. Telecommunications environments may offer preservice teachers opportunities to construct knowledge about how elementary students learn.

Mathematics Anxiety

Many adults can recall specific teachers or events from elementary school that contribute to their dislike and/or fear of mathematics (Frank, 1990). In fact, it has been suggested that a student's attitude toward mathematics is established by the time they reach the high school level (Hungerford, 1994; Reys & Delon, 1988). Therefore, elementary teachers play a very important role in developing a student's appreciation of and attitude toward mathematics (Larson, 1983). Hungerford said, "Elementary teachers who don't know much mathematics, who have little interest in what it means to do mathematics, and who are afraid of mathematics, are not likely to engender positive attitudes toward mathematics in their students" (1994, p. 16). Reys & Delon also suggest that the attitudes toward mathematics held by teachers are transmitted to students (1988). Certainly if these concepts are true, then teacher preparation programs need to address the issue of anxiety and attitude toward mathematics.

Aspects of mathematics such as precision, logic, and an emphasis on problem solving make the subject anxiety provoking for many individuals (Richardson & Suinn, 1972). And although anxiety is not limited to teachers, elementary teachers and elementary education majors exhibit high levels of anxiety toward mathematics when compared to others (Becker, 1988; Conrad & Tracy, 1992; Kelly & Tomhave, 1985; Wood,

1988). In fact, Kelly & Tomhave found that elementary education majors had higher levels of anxiety toward mathematics than college students with any other majors (1985). Prospective elementary teachers are typically more anxious about teaching mathematics than they are about teaching other subject areas (Ball, 1988). If mathematics anxiety is not addressed, then future elementary school teachers may be hindering the growth of mathematical problem solving skills among the children they teach instead of helping it.

The NCTM Professional Standards suggest that it is important for elementary teachers to have a solid understanding of mathematical principles and of the general nature of mathematics (NCTM, 1991). This is supported by others as well (Rasch, Finch, & Williams, 1992; Schwartz & Riedesel, 1994; Stoddart, Connell, Stofflett, & Peck, 1993). Because of the high anxiety levels towards mathematics, however, many future elementary teachers choose not to take the upper level mathematics courses that may help them to develop this solid base of understanding (Ball, 1988; Hungerford, 1994). Therefore, mathematical knowledge and mathematical anxiety are quite often related.

Preservice teachers often associate their likes and dislikes of math with the level of success and understanding that they experienced in their own mathematics classes (Garner-Gilchrist, 1993; Raymond & Santos, 1995). Likes and dislikes may, in turn, be reflected in teaching practices. Several studies have demonstrated that the beliefs held by teachers about mathematics, learning, and teaching can all have a profound influence on their behavior (Grouws, 1985 ; Silver, 1985). Conrad and Tracy reported that elementary teachers with high anxiety levels toward mathematics scheduled less time for mathematics than those teachers who were more comfortable with the subject (1992). They also explained that teachers manifesting high levels of mathematics anxiety were more likely to use traditional behaviorist teaching methods and avoid practices that were more consistent with the approaches advocated by the NCTM. It is possible that teaching style is contingent upon comfort levels, and the exploratory environment that is a part of a constructivist classroom may be very threatening to a teacher who has a high level of anxiety toward mathematics (Greenwood, 1984).

Conrad and Tracy suggest that making teachers aware of the extent and origin of their own anxiety and beliefs toward mathematics can be very helpful in preparing them to create more positive learning experiences for their own students (1992). "When teachers are aware of their own math anxiety, they can monitor their

actions in the classroom to avoid creating the same anxiety in their students" (p. 6). These researchers investigated the effects of an experience-based mathematics teaching methods course on the anxiety levels of preservice teachers who were preparing to become elementary teachers. The preservice teachers in the course had the opportunity to experience many hands-on mathematical activities, as well as to participate in a field experience with elementary children. They learned not only how to teach elementary mathematics, but they also gained further understanding of many basic mathematical concepts. In addition, the mathematics anxiety levels of the preservice teachers were significantly reduced after taking this course. These results suggested that experienced-based mathematics methods courses may not only help to prepare elementary education majors to teach mathematics, but this type of course structure may also address their anxiety levels as well. The teaching methods course described in this study was structured similarly to the one researched by Conrad and Tracy.

The telecommunications activity in this study was an attempt, among other things, to address the anxiety levels of the preservice teachers. There were no face-to-face interactions, so the preservice teachers had time to think before acting or responding. They could reflect on the messages sent to them by the elementary students. They also had control over the situation--they did not need to deal with discipline problems and instead could focus on the problem solving aspect of the activity. The medium of telecommunications provided an environment different from traditional classrooms. The study looked at how mathematical anxiety levels influenced how preservice teachers responded to this environment.

The Internet and Telecommunications

The Internet is a network of networks that connects computers around the world in a way that allows for the sharing of information. The Internet had its beginning in 1969 as ARPANET, a network developed by the Advanced Research Projects Agency of the U. S. Department of Defense so that researchers could login and run programs on remote computers. This network became much more than that very quickly as researchers discovered that they could share information through electronic mail, file transfer, and electronic interest groups (Kehoe, 1992).

In 1983, ARPANET was split into two separate networks, and together they formed the Internet. The U. S. Department of Defense mandated the use of the TCP/IP protocol suite so that more networks could be added to the Internet without the current network being affected. Since that time, the Internet has grown exponentially in terms of the number of networks connected to it, as well as the number of users who access it (Kehoe, 1992).

Until recently, educational acceptance and adoption of the Internet has been minimal despite its widespread use and popularity in the governmental and scientific community. Schools are now, however, desperately trying to obtain funding for phone lines, modems, and service providers that will provide them access to this network of networks. In 1991, the National Science Foundation sponsored a meeting of leaders from state Education Departments, universities, and public and private organizations and foundations. This group highly recommended not only the expansion of the Internet into schools, but also federal assistance in doing so (Russett, 1994). Telephone companies and online commercial services have also taken steps to bring Internet capabilities into schools (Ivers & Barron, 1994). However, the use of the Internet for the sake of innovation alone may be dangerous; it is worthwhile to examine the way telecommunications is used in learning contexts (Raymond & Santos, 1995).

Telecommunications, the communication across distances using personal computers, modems, and phone lines to connect to computer networks and the Internet, is one of the fastest growing areas of computer technology today (D'Souza, 1992). Telecommunications is a form of distance education, yet it also encompasses some of the characteristics of face-to-face instruction. At the same time, it is not completely consistent with either of these environments. Because of this unique combination of features, the learning environment that telecommunications creates is different from more traditional learning environments.

It is possible that the introduction of telecommunications into education may bring about many changes in the entire educational process. If the instructor, for example, asks a discussion question, the computer can prevent a student from seeing or hearing other answers until his or her own answer has been supplied (Harasim, 1990). This technology introduces other options for teaching and learning as well. We have moved from using telecommunications as merely a delivery system to "...seeing it as a means to support

collaborative conversations about a topic and the ensuing construction of understanding" (Brown, 1989 as cited in Harasim, 1990, p. 54). Telecommunications has altered the image of a classroom in that the walls of the classroom are now expanding to include the entire world (Kurshan, 1991).

Another of the attributes of telecommunications is that it is time-independent, unlike face-to-face interactions (Harasim, 1990). This enables users to participate at a time and pace convenient to them, which affects the learning process. Because it is time independent, the learner may read and reread a message many times before formulating a response. The learner is not forced to answer immediately, so they can wait until they are able to clearly express themselves before composing their response (Casey, 1994; Fennema & Franke, 1992). However, this can also be a negative aspect of the Internet environment as well, according to Harasim (1990). When a response is not received immediately, the sender may feel ignored or rejected. It is also possible for them to be confused about whether a topic is still current or if it has been overtaken by another theme.

The electronic environment is one where students may write holistically better than they do when the audience is composed only of their teacher (Allen, 1995; Fox, 1993; Harasim, 1990). This was found both when middle school students wrote documents to preservice teachers and when middle school students wrote essays with the understanding that they would be posted on an electronic bulletin board for others to read (Allen, 1993; Cohen & Riel, 1989). Providing an audience for writing had a positive effect on the quality of the students' writing.

The electronic environment may benefit both elementary students and preservice teachers. An activity paired preservice teachers who were enrolled in a secondary reading teaching methods course with eighth grade students in a "virtual field experience" (Allen, 1995, p. 115). The activity took place using both e-mail and two-way video, so that written, voice, and visual communication could be exchanged. This activity allowed the preservice teachers to understand what the eighth graders read and wrote about. "The technology allowed a one-to-one interactive arrangement that gave the preservice teachers a chance to understand the students with whom they were paired and to follow the students' development and growth as readers and writers throughout the semester" (Allen, 1995, p. 115). In another study by Allen, the use of telecommunications was shown to have

positive effects on both fifth graders and preservice secondary English majors (1993). The fifth graders improved their writing skills while the preservice teachers developed skills in diagnosing potential writing problems.

Despite the positive aspects of telecommunications, not all types of communication can be effectively reproduced through electronic means. Casey said, "compassionate looks, deep sighs, and other forms of 'body language' that often help to tell a more complete story do not translate well on a computer screen" (1994, p. 9). When preservice teachers are linked with elementary students, this may become very evident, especially when the elementary students are solving mathematical problems. The preservice teachers may not be able to see the charts, diagrams, and manipulatives that the learners used to help them solve the problem, or know how much time they spent dealing with a particular problem.

Telecommunications is ultimately a communication device that is distinguished by the social nature of its environment (Harasim, 1990). This has several implications for education. The NCTM stresses the importance of the communication process in several forms, including both writing and speaking, where students communicate their understanding of a mathematical concept. Electronic mail can foster this type of communication.

Since telecommunications activities are becoming more prevalent in schools, there is a need to explore what the technology can do to help prepare teachers. It may be found to be a limiting environment because the preservice teachers can only read the written thoughts of the elementary students rather than seeing and hearing more of their communication. This may, however, be enough for them to develop an understanding of the thought processes of the elementary children, especially with respect to mathematical problem solving.

Summary

One of the main ideas behind a constructivist approach to teaching and learning is that learners actively construct their own meaning of a situation. This meaning is based on their previous experiences and understanding of other events. It is a different approach than what has been traditionally implemented in schools. However, the NCTM Standards are based on the notion that the instructional practices used in

mathematics curriculums in the past no longer adequately prepare learners. The NCTM Standards were created to foster a conceptual understanding of mathematical ideas, rather than merely procedural understanding.

Another of the main facets of a constructivist approach is the idea of authenticity. Learning occurs in environments and through activities that are perceived to be authentic. These activities need to be "real" to learners and also to empower and challenge them. A constructivist approach to teaching and learning would attempt to include activities viewed as authentic by the learners as a part of the learning process.

The constructivist approach may be important in helping children to understand mathematical ideas. It may also be equally important in teaching methods courses where the goal is to prepare future teachers in particular content areas. Many preservice teachers do not have models of constructivist practices from their own education experiences. A constructivist approach in the teaching methods course may help to not only model effective practices, it may also help the preservice teachers develop an understanding of mathematical concepts. In addition, a constructivist approach may help them to understand how children think and learn.

The use of telecommunications has only been recently explored as an instructional tool. Because it is a different type of medium than other communications tools, it is important to examine some of the characteristics of e-mail for its value in helping preservice teachers learn about elementary students. This tool facilitates an interesting relationship because although people are not communicating with each other face-to-face, they are often honest and open in their written communication. Also, the nature of the reflection time that is a part of this type of communication is such that it enables people to think more before responding. This may have both positive and negative elements, but is worth exploring as a tool to help better prepare preservice teachers to teach mathematics to elementary children.

Telecommunications activities have the potential to address the NCTM's Communication Standard. This Standard suggests that it is necessary to encourage students to verbalize their mathematical understanding through a variety of modes. Writing is one such mode. Writing also enables teachers to gain a sense of the child's understanding as well. In terms of helping preservice teachers, the writing done by elementary students through an electronic link may help better prepare them to understand the thought process of elementary students that go on in problem solving situations.

Activities that use the telecommunications medium may be valuable resources in teacher education programs. There is lots of documentation suggesting that elementary teachers are inadequately trained to teach mathematics. There may be several factors responsible for this, but ultimately it is cause for concern. Teachers need to become familiar with a constructivist approach to teaching mathematics, and this may not happen without authentic experiences of their own to help them see and understand how children react to mathematical situations. Links to children through telecommunications-based activities may provide these authentic experiences.

In addition, anxiety toward mathematics may also play a significant role in the teacher preparation process. Preservice teachers come from learning environments where drill and practice was the most prevalent instructional activity in mathematics learning. As a result, many of them have very negative attitudes toward the subject, and their anxiety levels are high. It has been found that the way teachers teach is influenced by their anxiety levels, so it is important that methods courses address anxiety levels.

CHAPTER III. METHODOLOGY

The purpose of this chapter was to describe the methodology used to examine the study's research questions. It includes six sections: 1) an introduction to the methodology, 2) the research procedures used, 3) the participants in the study, 4), the instruments used in the study, 5) the data analysis, and 6) a summary.

Introduction

This study examined the effects on elementary education majors of their involvement in a telecommunications activity linking them with elementary students in a mathematical environment. Several elements were explored, including whether the preservice teachers viewed the activity as an authentic learning experience, the nature of the problems they chose to send to their student groups, and whether there were differences with respect to the perception of and involvement in the e-mail activity between preservice teachers with high and low levels of anxiety toward mathematics. Several methods were used to examine these items. Most of the data collection followed a qualitative approach in order to provide a rich description of the results.

The underlying beliefs regarding the nature of reality influence the type of approach used in any research project and that is why qualitative methodology was used in this study (House, 1994). It was considered important to develop an understanding of the reactions of preservice teachers to an e-mail activity that was a part of an elementary mathematics teaching methods course. The focus of the study was not to establish cause and effect between certain elements of the mathematics teaching methods course and the preservice teachers' involvement in the e-mail activity. Rather, the multiple realities among the participants in the e-mail activity were considered for what they could contribute to other telecommunications-based activities. I undertook the research as the course instructor, and recognized the potential effect that my dual role could have on the results of the study.

The research approach used in the study allowed for some flexibility in the exploration of emerging issues as new information was discovered (Bogdan & Biklen, 1992; Borg & Gall, 1989). A small quantitative element of the study provided supporting evidence for issues that were uncovered in the qualitative exploration.

Although the combination of qualitative and quantitative data is often debated, documentation exists suggesting that the two types of approaches can help to inform each other in a way that may better represent the context with fewer biases than either approach alone (Borg & Gall, 1989; Goetz & LeCompte, 1984; House, 1994; Reichardt & Rallis, 1994). The two research traditions have differing limitations yet they share in the goal of understanding a situation; therefore, they can each add valuable information to any study. This was the rationale behind employing both methods in this project.

Procedures

The setting

The mathematics teaching methods course was taught from a constructivist perspective. As in the study conducted by Garner-Gilchrist, the practicing teachers who were involved in this course were encouraged to talk, listen, read, and write about mathematics (1993). They used manipulatives extensively to help them connect concrete and abstract mathematical concepts. They created mathematical problems for their peers to solve, within established parameters. They demonstrated their understanding of concepts through projects flexible enough to allow them to address the grade levels and mathematical content of interest to them.

The preservice teachers were informed of the structure of the e-mail activity on the first day of the mathematics teaching methods course. They were notified of their required participation, but were also informed that they may choose to exclude any part of their participation in the activity from the research project with no effect on their grade. Additionally, the preservice teachers were provided with a description of how the e-mail activity factored into their overall course grade. A detailed announcement of how their participation would be evaluated, including the rubric that would be used to evaluate their participation, was included in their course packet of materials.

During the second week of the semester, one class session was spent specifically focusing on non-routine problem solving. A relatively large element of this class was a discussion of problem solving, as emphasized in the NCTM Standards (1989). Included in this discussion was a description of non-routine problems. Heuristic strategies were discussed, as were methods of helping children develop mathematical

problem solving skills. Examples of problems that would be considered appropriate based on these criteria were presented. Although a large part of the course consisted of hands-on activities and small group explorations of problem situations, this introduction to mathematical problem solving involved very little actual preservice teacher interaction. Throughout the remainder of the mathematics teaching methods course, problem solving was discussed as it related to different broad mathematics concepts such as fractions and geometry, and the preservice teachers were much more involved in hands-on activities than they were in this initial discussion.

During the fifth week of the course, the preservice teachers learned how to forward and carbon copy electronic messages, so that they could forward all of their transcripts throughout the e-mail activity to me for research purposes. Written instructions explaining the e-mail process were made available for class members; however, only two of the preservice teachers requested the materials. Elementary student groups were chosen by the preservice teachers during this week, and a second discussion of appropriate and non-appropriate problems as defined by the NCTM occurred. Possible sources for the preservice teachers to use to locate problems to send to their elementary student groups were suggested. Several examples and non-examples of good problems were shown to the preservice teachers. The preservice teachers were asked to orally explain their perception of each of these items as being appropriate or not appropriate for their student groups.

At the end of this week and for the remainder of the semester, the preservice teachers sent a new problem to their elementary student groups. The elementary students worked in their groups to solve the problem, and then they responded to their preservice teacher "buddy" with their solution and an explanation of the process they used to obtain their answer. The preservice teachers provided feedback to the elementary student groups based on these responses.

In addition to sending and receiving mathematical problems and solutions, there was also a great deal of other communication that occurred between the college students and the elementary students during the e-mail activity. The preservice teachers were required to share information about themselves, world events, or anything else that they chose with their elementary student groups. It was hoped that the elementary students would help the preservice teachers get to know them better as well by including personal communication with their

messages. Some of the elementary students did, in fact, include lots of personal comments in their messages. Others did not include very much in their messages except the information about their problem.

This research project was reviewed and approved by the Iowa State University Human Subjects Committee.

The research design and methodology

The Mathematical Anxiety Rating Scale (MARS) instrument was administered during the first week of the semester. Based on the results of this instrument, three preservice teachers with low mathematical anxiety levels and three class members with high levels of anxiety toward mathematics were selected to be case study participants. Their agreement to participate meant they would be interviewed four times during the e-mail activity, in addition to the same participation that the other preservice teachers had with the e-mail activity. The purpose of choosing participants with varying degrees of anxiety toward mathematics was to determine if anxiety levels had any effect on their perception of and involvement in the e-mail activity. The results on the MARS instrument were discussed with the case study participants in the initial interview; no other class members were informed of their anxiety scores.

ACT-Math scores were collected before the preservice teachers were paired with the elementary students. The first administration of the Problem Set was also done prior to the beginning of the e-mail activity. Photographs of each of the preservice teachers were taken and developed during the week prior to the beginning of communications with the elementary students.

During the fifth week of the semester, which was the first week of the e-mail activity, the preservice teachers were each paired with two elementary student groups. Preservice teachers majoring in Early Childhood Education were paired with elementary students in grades three and/or four, and the class members majoring in Elementary Education were paired primarily with students in grades five or six. During this week, the preservice teachers reflected on and wrote about the mathematical and problem solving skills they believed their student groups would have. They forwarded their documents to me electronically for analysis. The photographs were labeled and sent to the appropriate elementary schools. The first set of interviews with the case study participants was completed during this week, and the Problem Set was sent to each of the participating teachers

for evaluation. The first message was sent by the preservice teachers to the elementary students at the end of the week.

During the third week of communications with the elementary student groups, all of the problems sent to the elementary student groups were compiled and forwarded to the respective participating teachers to rate. The participating teachers were asked to rate the problems based on the appropriateness scale used on the Problem Set. The course instructor also rated the problems. Both sets of ratings were shared with the preservice teachers. This same rating process was conducted during the ninth week of the e-mail activity as well.

After the sixth week of communication with the elementary student groups, the preservice teachers were asked to electronically forward to me a transaction they viewed as problematic, along with an analysis of why they chose this message. They were also asked to identify and forward a positive interaction, along with an explanation of their choice. Both the problematic and positive interactions were compiled and analyzed.

Interviews were completed prior to the e-mail activity, and again during weeks three and six to focus on the preservice teachers' perceptions of their role in the e-mail activity. The final interviews took place after the completion of the activity. The preservice teachers wrote about their perceptions of the e-mail activity as a whole, and they provided a comparison and contrast of the e-mail activity to their practicum experience. The timeline in Figure 1 illustrates the research procedures used during data collection.

The Study's Participants

The preservice teachers

The primary participants in the study were elementary and early childhood education majors who were enrolled in a methods of teaching mathematics class at a large midwestern university. There were 28 seniors enrolled in the course during the fall, 1995 semester. Only three of the class members were males. Most of the preservice teachers enrolled in the mathematics teaching methods course were scheduled to do their student teaching in Spring, 1996. The others planned on student teaching during the Fall, 1996 semester. In addition

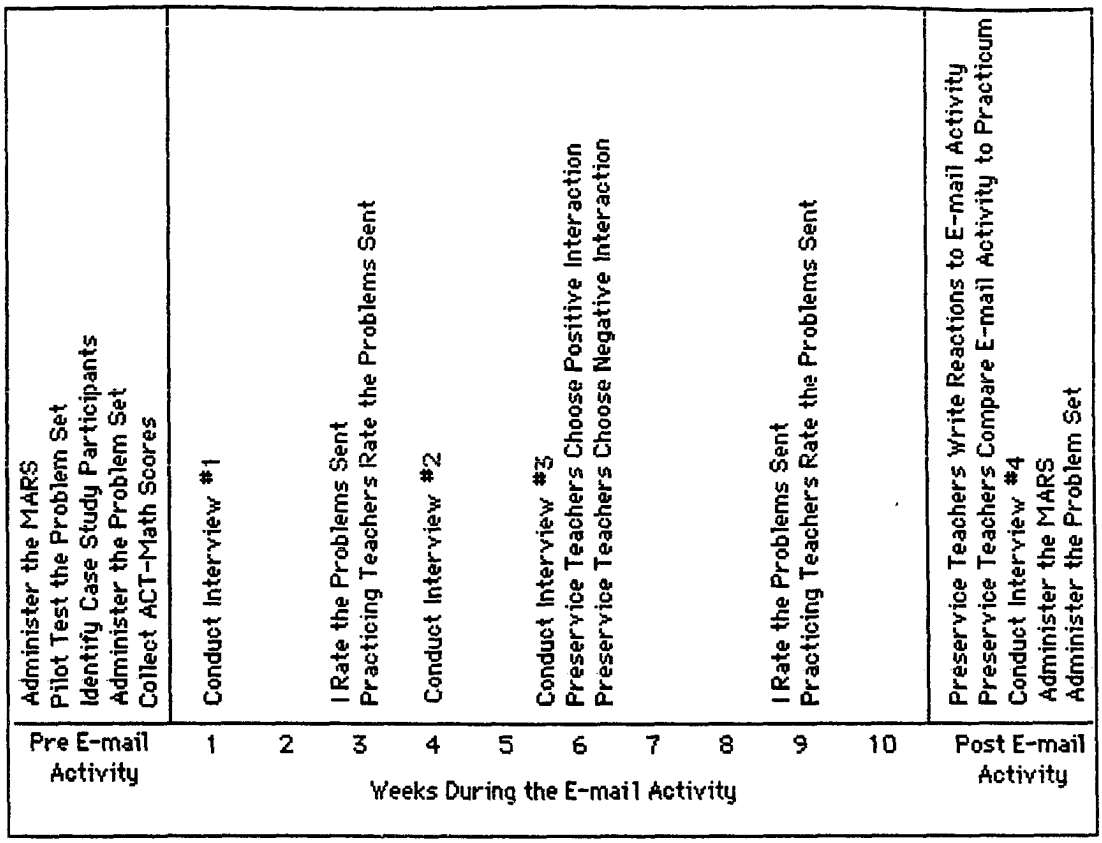

Figure 1. Timeline of data collection prior to, during, and after the completion of the e-mail activity.

to their enrollment in the mathematics teaching methods course, the preservice teachers were also required to enroll in a science teaching methods course and in a field experience with a placement in an elementary classroom during times scheduled for mathematics and science activities.

The participants were similar to education majors at other universities in terms of their mathematical anxiety. Their overall MARS score was 225.96 (N=28, *SD* = 55.25) at the beginning of the semester and 204.35 (*SD* = 57.71) at the end of the semester. These scores were comparable to the anxiety scores measured among preservice teachers at other institutions (Conrad & Tracy, 1992; Kelly & Tomhave, 1985). The net decrease in anxiety levels over the semester was also similar to that found by Conrad & Tracy (1992).

Prior to taking the mathematics teaching methods course, the preservice teachers had completed coursework in general teaching methods, foundations of education, and methods of teaching in content areas such

as social studies and language arts. Several of their earlier teacher preparation courses included field experiences in area schools. All but one of the class members had previously taken an introductory instructional technology course and were familiar with the use of electronic communications. The preservice teacher who had not yet taken the technology course was enrolled concurrently with the mathematics teaching methods course.

Several types of data were collected from each of the 28 participants, as detailed in the Procedures section of this chapter. In addition to data collected from all class members, six case study participants were examined in greater detail. These six case study participants were selected based on their MARS scores. The three class members identified as having the most initial anxiety toward mathematics (Chelsea, Jessica, and Emily) and the three with the least amount of anxiety toward mathematics (Lori, Michan, and Erin) were asked to participate in a series of four individual interviews. All six of these preservice teachers agreed to participate. In addition to their participation in the interviews, these six case study participants also agreed to forward to me all of the messages that they sent to and received from their elementary student groups.

All six case study participants were women. Since there were only three males in the course, this sample was representative of the preservice teachers in the class. Because the reactions of the preservice teachers to the e-mail activity may have been influenced by their mathematical anxiety levels, the case study participants were knowingly selected for their extreme high or low anxiety levels. It was not intended that the selection sample be random, but instead be based on criteria that could best contribute to the research (Borg & Gall, 1989; Goetz & LeCompte, 1984).

The elementary students and teachers

The secondary participants of the study included the actual elementary students and their classroom teachers. Elementary teachers were solicited to participate in the electronic mail activity through postings on several electronic bulletin board systems read by elementary and secondary teachers. A total of ten teachers participated from eight different sites around the country during Fall, 1995. Three of the teachers who volunteered had participated in the e-mail activity during previous semesters. The other participating teachers had their first experience with the e-mail activity during this research study. A brief description is offered for

each of the sites. These descriptions are based on written messages provided by each of the participating teachers.

The site with the youngest students was Silverton, Oregon. There were 21 students in this class of third graders. Their teacher considered them to be above-average in terms of their mathematics skills. The city was a small town, population 5,000, outside of Salem. Of the case study participants, Chelsea, Jessica, Michan, and Erin each communicated with groups of students at this location.

Fourth graders from an urban setting outside of Newport, Virginia also participated in the e-mail activity. There were 21 students from this school, primarily from low-income families. The students were poor readers and had not done much work with mathematical problem solving prior to their involvement in the e-mail activity. Chelsea, Jessica, Michan, and Erin also each were paired with groups from this site.

Drexel Hill, a suburb of Philadelphia, provided 33 students in grades four through seven for the activity. The participating institution was a small, private Catholic school. Students were placed in mathematics groups depending on their grade and skill levels. Two teachers from Drexel Hill participated in the e-mail activity during Fall, 1995; their students had also participated in the e-mail activity the previous year. The two teachers from this school felt that the e-mail activity benefited their students to the extent that they wrote an article about how their students were affected by their involvement with the college student partners (Brennan & Yantosh, 1996). Emily and Lori sent messages to Drexel Hill students.

Fifth graders from Juneau, Alaska, population 28,000, sent messages to both Emily and Lori along with several other preservice teachers. The classroom teacher and the students participated in the e-mail activity the prior year as fourth graders. They had done quite a bit of work developing problem solving strategies.

Several other sites were used in the e-mail activity; however, none of the case study participants were paired with these groups. There was one group of two gifted boys from Halsey, Oregon who participated. Halsey was a very small rural district in the western part of Oregon. Fargo, North Dakota provided a class of 28 sixth grade students for the preservice teachers to correspond with. This group was composed of high ability mathematics students from this city of 74,000. Fifth graders from Camden, New Jersey, another suburb of Philadelphia, also participated in the activity, as did several students from Jericho, New York, located on Long

Island. The students from Jericho were low-ability fifth graders. Their teacher and the computer coordinator at the school helped the students with the technology and with the development of problem solving skills.

The researcher

Because the perspective of researchers is shaped by their environments, I believed it was important to share my background and biases that may have influenced my interpretations as a secondary participant (Hedrick, 1994). I was the instructor of the elementary mathematics teaching methods course that was the focus of the study. I had a strong background in mathematics, majoring in secondary mathematics education as an undergraduate. While teaching secondary mathematics in public schools, I developed an interest in the use of technology in education, and began pursuing a higher degree in educational technology. After completing a master's degree, I continued working at the university as an instructor, and taught the elementary mathematics teaching methods course as well as various courses in educational computing. In addition, I managed the computer laboratories in the Curriculum and Instruction Department at Iowa State University. Because of my interest in technology, I made an effort to integrate technology into the curriculum in the mathematics teaching methods course whenever possible.

I created and initially implemented the e-mail activity during the second semester that I taught the mathematics teaching methods course. The activity described in the study was the fourth time it had taken place. After each semester of participation, revisions and alterations were made to the design of the activity in an attempt to make it more valuable for both the preservice teachers and the elementary students.

Because of my involvement with the elementary mathematics teaching methods course and my background in both mathematics and technology, I felt that I would be able to understand the preservice teachers' involvement in the e-mail activity (Bogdan & Biklen, 1992; Borg & Gall, 1989). In addition, my relationship with the preservice teachers as their instructor allowed me to make observations of their participation in the mathematics teaching methods course, as well as to consult with them in an instructor-student relationship. At times, this yielded interesting information that an outside researcher may not have discovered. On the other hand, the preservice teachers may also have been more aware of my research agenda and may have tried to act accordingly.

I firmly believed in the constructivist approach to teaching and learning, and felt that I modeled the approach advocated by the NCTM. The attitude in the course was relaxed, and the preservice teachers seemed to feel comfortable sharing their thoughts and ideas. The preservice teachers often worked in groups using many of the same manipulatives that the NCTM suggested would benefit elementary students in their understanding of mathematical ideas. I received recognition for my teaching from the university president in Fall, 1995.

I developed a good relationship with the preservice teachers in the mathematics teaching methods course. The college students often visited my office to discuss situations that occurred during their field experience, and also for suggestions regarding course assignments. Because they felt comfortable using e-mail, many of the preservice teachers solicited help through this medium as well. One-third of the class members asked me to write letters of recommendation to include in their credential files, an indication that they felt comfortable with me and that they felt I knew them well enough to write such a letter.

The Instruments

Mathematics Anxiety Rating Scale

The MARS scores were used to get a general sense of the anxiety toward mathematics held by the preservice teachers. The scores were also used in the selection of case study participants. The MARS (Suinn, 1972) was a 98-item scale listing a variety of life situations that involved dealing with numbers in one way or another. Students indicated the level of anxiety or tension associated with each of these items using a 5-point scale from "Not at all" to "Very much." In scoring, values from one to five were assigned to each response, then summed. Thus, scores could range from 98 to 490. High scores indicated more anxiety toward mathematics than low scores. The MARS instrument is included in Appendix A.

Suinn & Edwards found a coefficient alpha on the instrument to be 0.97 (N = 397) indicating a high average intercorrelation of the items dominated by a single factor, presumably mathematical anxiety (1982). Construct validity had been determined through a comparison of scores on the MARS test with grades in several mathematics courses, and also by using a factor analysis (Suinn & Edwards, 1982). Their test-retest reliability

coefficient was 0.78 after two weeks ($p < .001$). The mean MARS score for a normative group of adults selected by Richardson & Suinn (N = 397) was 215.38, with a standard deviation of 65.29 (1973).

The mean MARS score for the class when the instrument was administered prior to the e-mail activity was 225.96, $SD = 55.25$. This was not significantly different from the normative group ($t = .918$). The class mean was similar to the results when Kelly & Tomhave (1985) administered the instrument to elementary education majors at another institution ($M = 230.0$; $t = -.351$). The scores for participants in this study ranged from 123 to 334. When the MARS scale was given during the last week of the course, the mean score was 204.35, $SD = 57.71$. The range on the second administration was 108 to 324. There was a significant difference between the mean MARS scores on the first and second administration, $t(22) = 2.61$, $p < .05$. This indicated that the amount of mathematical anxiety among the preservice teachers decreased by the end of the semester. It was likely that several factors contributed to the decreased anxiety level including the use of manipulatives to help in the understanding of not only how mathematics should be taught to elementary students, but also to develop a better understanding of the mathematical concepts among the preservice teachers (Conrad & Tracy, 1992). Participation in the e-mail activity may have also been a contributing factor, however, the study was not designed to examine specific factors that contributed toward the decreased levels and rather was constructed to provide a detailed description of involvement in the e-mail activity alone.

In this study, the three preservice teachers with the lowest scores on the MARS had indices ranging from 123 to 132 on the first administration of the instrument. At the second administration, their scores ranged from 108 to 144. All of these scores were in the lowest decile of Richardson & Suinn's normative group (1973), indicating their confidence in their mathematical ability. The class members with the three highest scores were those whose indices ranged from 296 to 330 on the first testing, and 227 to 324 upon the second administration. Their first scores were in the ninetieth percentile of the normative scores (Richardson & Suinn, 1973). Out of these three scores, only the score of 227 was a significant change from the preservice teachers' first score.

Problem Set

To see how the preservice teachers' perceptions of appropriate problems changed during the semester, a Problem Set containing ten items was created and administered to the preservice teachers and also to the teachers who participated in the e-mail activity. The preservice teachers and the participating teachers rated each of the ten items on a scale of 1 to 5, with a 5 indicating that the item exhibited all of the qualities of an appropriate problem for a specific grade level, and a 1 indicating that it exhibited none of those qualities. In addition, there was space left underneath each of the items for written comments regarding each rating. The complete Problem Set is included in Appendix B.

This instrument was developed after pilot testing with two groups. One group was considered a field of "experts", and was used to establish construct validity. The group was composed of two instructors who taught sections of the mathematics teaching methods course, one university professor involved in mathematics education, two practicing elementary teachers, and one fifth grade student. Each member of the group of experts independently rated a set of twenty items for appropriateness and wrote comments regarding their ratings. Items that did not yield consistent ratings among the panel members were eliminated from the final version of the instrument.

The pilot Problem Set was also administered to the preservice teachers enrolled in a section of the mathematics teaching methods course that was not involved with the e-mail activity. These class members were not asked to write descriptions of their ratings, but they were asked to rate each of the twenty items using the five-point appropriateness scale. Descriptive statistics were calculated for each item. The means and standard deviations of the pilot group ratings were examined on the Problem Set items as well.

Items included on the final instrument were those rated consistently by the experts and also having a good variability when rated by the pilot group. Items with high overall ratings, low overall ratings, and average ratings were included. Ten items meeting those criteria were selected for inclusion in the actual Problem Set.

Ratings of problems sent

During the third and ninth weeks of the activity, all of the problems sent to the elementary students were rated by both the course instructor and several of the participating teachers. The purpose for rating the

problems was twofold. One reason was to help the preservice teachers develop an understanding of good mathematical problems to use with their groups of elementary students. Feedback from myself and the practicing teachers may have guided them in their problem selection. Another reason was to document any changes in the types of the problems sent by the preservice teachers to their group members. The problems were rated on the same 5-point scale as that used on the Problem Set items.

In addition to the numeric ratings, comments were made by me and by the participating teachers to explain our ratings. These ratings and comments were then shared with the preservice teachers to help provide them with feedback suggesting the appropriateness of their items. I rated the items based on the NCTM's criteria for quality mathematical problems, as well as my perception of the types of mathematical skills commonly found among children of the grade level being addressed. The practicing teachers focused less on the NCTM Standards and more, instead, on the types of items they considered appropriate for their students.

Transcripts of the interactions between the preservice teachers and elementary student groups

In order to develop a sense of the overall effect of the e-mail activity, all of the messages sent from the preservice teachers to their elementary student groups were electronically forwarded to me for analysis purposes. In addition, all of the messages that the elementary students sent to the preservice teachers were also forwarded. These interactions were monitored throughout the activity, but commented on only when the problems sent to the elementary student groups were computations. I felt that providing too much instructor feedback would inhibit the preservice teachers from formulating their own understanding of what encompassed good problems. Raymond and Santos recognized that this lack of direction was often a frustration for preservice teachers since they were accustomed to a more direct approach (1995). The rationale behind commenting on items that were simple computations was that it was evident that the preservice teachers did not understand the difference between computations and problem solving if they were sending items of this type, and more direct feedback to them was needed. These comments also helped keep the participating teachers happier, since they did not want computations sent to their elementary students. The problems were compiled on a weekly basis, so that an analysis of them could be made.

The interactions between the six case study participants and their student groups were more closely monitored than were the interactions of the other class members with their student groups. All of the messages that they sent and all of those they received were forwarded electronically to me and compiled. The case study participants were asked to comment on these transcripts in interviews two, three, and four.

For the purposes of grading, the preservice teachers' involvement in the e-mail activity was evaluated only on whether their communications were sent on time, that the messages included appropriate feedback to their student groups, and whether some personal communication was present in the messages. The preservice teachers were encouraged to send appropriate problems to their students and to learn from the feedback that the students provided them. However, the quality of the problems was not part of the evaluation process for their grade. This evaluation process was flexible enough to allow the preservice teachers to interact based on their comfort levels without too many restraints as a result of being tied to a grade. Only four of the preservice teachers did not receive all of the possible points for the activity, primarily because of sending late messages.

Written reflections

Asking the preservice teachers to reflect upon and write about aspects of their participation provided insight into their perception of the e-mail activity. During the sixth week of the semester, the preservice teachers were asked to choose a message or part of a message that they considered to be a positive interaction. They were asked to explain their rationale for selecting that particular message. In addition, the class members were also asked to select an interaction that they considered to be problematic in some way. This was also forwarded to me, along with an explanation of why that transcript was selected. The items that the six case study participants selected as their positive and problematic choices were discussed in the interviews.

At the completion of the e-mail activity, the preservice teachers wrote about several aspects of their involvement in the e-mail exercise. They were asked to expand upon both the positive and negative aspects of the e-mail activity as a whole, again to provide an understanding of their perception of participation in the activity. The importance of including both positive and negative elements of the e-mail activity was emphasized so that the preservice teachers did not feel intimidated by describing aspect of the e-mail activity that

they felt were limiting. It was explained that a critical evaluation included both positive and negative aspects of their involvement.

In addition to their positive and negative reactions to the e-mail activity, the preservice teachers were asked to discuss what (if anything) they learned through their involvement in the e-mail activity. Their responses were reinforced through a comparison of the e-mail activity to their practicum experience, which was also requested as part of the preservice teachers' reactions to the e-mail activity. The written reactions made by the six case study participants were discussed in the interviews with them.

Interviews

Individual interviews were conducted on four occasions with the six case study participants. The interviews were audio taped and then transcribed. A printout of each of the previous interview transcripts and e-mail messages was available to the case study participants during the interview process so that they could refer back to specific interactions if they so desired.

The initial interview was approximately an hour in duration, and it occurred during the first week of the e-mail activity. At the time of the interview, the preservice teachers had sent one message to their elementary student groups, but they had not yet received any responses back from them. The questions asked in this interview were designed to develop a better understanding of the preservice teachers' mathematics background and their attitude toward mathematics and teaching mathematics. The participants were also asked to elaborate on their perception of the kinds of mathematical skills they thought their elementary students would have. They were asked to expand upon their Problem Set ratings and comments on those items.

The second and third interviews were each thirty to forty-five minutes long and took place after three and six weeks of communications with the student groups, respectively. These discussions focused on the problems selected by the preservice teachers to send to their student groups. The participants were asked to explain the sources that they used in finding their items. Their problematic and positive interaction choices were discussed, as was their perception of their role in the e-mail activity. In addition, the case study participants were asked to explain how they responded to the messages sent by their elementary student groups. The case study participants were asked to rate the e-mail activity as an authentic activity.

In the final hour-long interview at the completion of the e-mail activity, the case study participants were asked to analyze the results of the second administration of the MARS. In addition, they were asked to expand upon their written explanations of the positive and negative elements of the e-mail activity, as well as their feelings regarding what they believed they learned through their participation in the project. The case study participants were also asked to discuss their practicum experience, and to provide a rating of how real their school placement was to them. Sample interview questions are included in Appendix C.

Chapter four includes the results of the interviews with the six case study participants. This chapter was sent to each of the preservice teachers who was interviewed, so that they could comment on the text. The intent of the chapter was to capture the sense of what the case study participants said during the interviews with respect to their participation in the activity. Changes were made in the text based on their written feedback, since the views of the subjects were an important part of the research (Bogdan & Biklen, 1992; Borg & Gall, 1989). Five of the six case study participants sent back written comments regarding their section of the chapter. Only minimal text and editing changes were suggested; they agreed that the chapter accurately reflected their involvement in the activity.

Data Analysis

Because of the qualitative design of this study, much of the data analysis stemmed from the transcripts of interviews and interactions between the preservice teachers and the elementary student groups. Statements made by the case study participants were solidified by examples from the other class members as well.

Quantitative data was also collected and analyzed in the study. The MARS index was computed and recorded for each student. The overall mean and standard deviation was also computed and compared with published results. In addition, the case study participants were selected based on their scores on this instrument. An alpha level of .05 was used to test the significance of results.

Data from the Problem Sets were collected and examined to determine if there were differences in the perceptions of the items as being appropriate. The ratings given on the problems sent by the preservice teachers during weeks three and nine were compared using means and standard deviations. T-tests were used to determine

if there were differences in preservice teacher ratings on the Problem Set and also if there were differences in the instructor and participating teacher ratings of the problems that the preservice teachers chose to send to their student groups. Since there were many t-tests computed comparing the preservice teachers with the practicing teachers, an alpha level of .001 was selected in these cases. A correlation was used to determine if there were differences in instructor ratings of the problems sent by the preservice teachers based on their mathematical anxiety levels.

The different types of data collected were used to triangulate the research findings (Goetz & LeCompte, 1984). Triangulation helps to pinpoint the accuracy of conclusions through the use of several sources of data. It also helps prevent the researcher from accepting the validity of his or her initial impressions without further substantiation. The researcher necessarily has biases. Triangulation assists in correcting these biases, since the different forms of data may be inconsistent with the initial beliefs of the researcher. In this study, data from the case study participant interviews, the written reflections from all class members, the problems sent, and the ratings of the Problem Set were used to generate an understanding of the preservice teachers' participation in the activity.

Summary

This study involved an examination of the preservice teachers' reflections of their participation in a telecommunications-based activity linking them with elementary students. In order to determine the perceptions of the preservice teachers, data was collected from several resources. Written reflections from all of the class members provided a comprehensive look of their opinions regarding several aspects of the activity. All of the problems sent each week were examined as well. The case study participants provided an in-depth examination of the study's research questions through a series of four interviews. Between the case study participants and the whole class data, a comprehensive picture of the preservice teachers' involvement in the e-mail activity was formed.

CHAPTER IV. CASE STUDY PARTICIPANTS

The purpose of this chapter was to describe the six case study participants and their involvement in the e-mail activity so that an analysis could be made. Rather than trying to combine all of the results and describe the activity in terms of a whole class reaction, I felt it was important to document the ways that the unique individuals with different fears, anxieties, and experiences perceived the e-mail activity.

The chapter is organized into seven sections, one for each of the six case study participants and a summary section. Each of the case study participant sections is further divided into the following subsections: 1) personal background with respect to mathematics and teaching, 2) the elementary student groups, 3) problem selection, 4) problematic and positive interaction selections, 5) authenticity of the e-mail activity, 6) an overview with respect to the research questions.

Chelsea

Personal background

Chelsea was fairly quiet and reserved in class but was very vocal during the interviews. She always wanted to be a teacher and was most interested in teaching students in grades two through four after completing her certification. The middle elementary grades appealed to her because students at those levels have enough academic skills needed for doing interesting activities and yet they still have an excitement for school.

Chelsea was identified as having a high level of anxiety toward mathematics. In fact, her MARS score of 330 was the highest in the class. Chelsea claimed that this number accurately reflected her feelings toward mathematics. "Math was always hard for me, and it made me nervous. It wasn't that I was bad at it; I was just nervous about it." She claimed mathematics was fine for her until she had a negative experience with the subject in seventh grade. She could not remember exactly what happened other than that her parents had to go to the school because of the situation. This repressed memory changed her view of mathematics.

High school mathematics was even worse for Chelsea. She developed mononucleosis as a freshman and had to miss a month of school. This was a lot for her to miss in algebra, since she struggled with the

concepts even when she was present. Although she eventually got an "A" in the course, Chelsea felt that the grade was the result of a sympathetic teacher rather than her mastery of the material. She considered her second algebra course to be a nightmare, partly because she did not want to be in the course and partly because of what she missed the previous year. Chelsea felt that poor teachers contributed toward her lack of expertise and her negative attitude toward mathematics.

All new college freshmen at the university were required to take a placement test to determine the appropriate mathematics course for them to take. Chelsea did poorly on the exam and was placed in a remedial course that did not count toward her degree. As an alternative to the non-credit course option, her advisor suggested taking a mathematics course for elementary school teachers at an area community college. This was what Chelsea chose to do, and she felt that the course helped her to better understand mathematics. The teacher of the course taught in a manner that was not intimidating to her; Chelsea was more at ease about mathematics as a result.

Chelsea felt that her negative attitude toward mathematics would affect her teaching, but surprisingly she thought it would make her a better teacher. She said that her disposition toward mathematics made her realize how important it was to provide a strong mathematical foundation for her students. She thought about ways that she could help students to understand the subject and have fun with it–things that were missing from her own educational experiences. But even the positive things she could offer to students did not outweigh her uncomfortableness with teaching mathematics to children.

The student groups

In the e-mail activity, Chelsea was paired with two groups of students who had not previously participated in the project: a group of third grade students from Oregon and a group of fourth graders from Virginia. When asked about the mathematical skills she thought these children would have, she could think of only addition and subtraction and other operations involving large numbers. She thought the students should be able to read the problems and figure out which numbers to calculate, as long as the item was not too hard. Chelsea felt that it would be a challenge for her to find appropriate problems to send to these students. This

uncertainty was understandable considering the limited mathematical skills she considered to be within their range. Her response also clearly documented her perception of what mathematics involved–only computations.

Because of Chelsea's lack of experience in selecting appropriate materials for her students, she indicated that she would initially use scope and sequence charts and mathematics textbooks to get a sense of what might be appropriate for this age level. She said that she would use the students' feedback to help her choose items once the activity began. Although she was somewhat uncomfortable with her ability to select good problems, Chelsea thought that the activity would be a fun experience for her. She believed that it would be inviting for the elementary students as well, and that engaging students was a part of her role in the e-mail activity.

Problem selection

Prior to the start of the e-mail activity, Chelsea said that good problems were real-life problems. She felt that, "It's important [for the students] to actually know what the numbers represent," rather than solving contrived word problems. In addition, being able to draw a picture to depict information from a problem was also an important characteristic of a problem to Chelsea. Most of the items that she sent involved situations that the children could relate to, and several of them were items where pictures or drawings may have helped the students in their solving process. Chelsea addressed the qualities she specified for good problems in her selection process.

Table 1 lists the problems that Chelsea chose to send to each of her groups throughout the e-mail activity, as well as the sources she used to locate the problems.

The pattern of where Chelsea located her problems illustrated her comfort level with this activity. The problems that Chelsea sent during the first week came from a textbook teacher's manual. Because Chelsea was unsure of her groups' mathematical skills, looking in textbooks seemed to her like a good way of learning more about the kinds of skills that could be expected at the third and fourth grade levels. For the next three weeks, Chelsea sent problems that she created. The problems were consistent with the content in the mathematics textbooks she explored, and they were based on items discussed in her teaching methods classes. The problems sent during those weeks were also consistent with her specified qualities of good problems.

Table 1

Chelsea's Weekly Problem Selections.

Week	The Problems Sent	Sources Used
1	For Oregon: Three children are collecting sea shells on the beach. Two of the children collect 42 shells each and the third child collected 35 shells. Did the children collect more than 100 shells in all? How many shells did they collect? The children's parents told them they could only bring 50.	Teacher manual from textbook.
	For Virginia: Communication is important between space stations. A call between stations costs $5.00 for the first 3 minutes and $2.00 for each minute after that. What is the cost of a call that began at 7:35 and ended at 7:44?	Teacher manual from textbook.
2	For Oregon: Andrea, Dustin, Alex, and Jared decided to walk from the capital of Oregon, Salem, to the capital of Iowa, Des Moines. This distance was 1,400 miles. Andrea, Dustin, Alex, and Jared walked 10 hours a day for 21 days before they got too tired to go on. After finding out how long it takes an average person to walk one mile, figure out how many miles they walked before they go too tired to continue. If they took the most direct route to Des Moines, what state did they get to when they stopped walking?	Made up; based on discussion in her social studies teaching methods course.
	For Virginia: DeMarea, DeAndre, and John decided to walk from the capital of Virginia to the capital of Iowa. DeMarea, DeAndre, and John walked 10 hours a day for 21 days before they got too tired to go on. After finding out how long it takes an average person to walk one mile, figure out how many miles they walked before they go too tired to continue. If they took the most direct route to Des Moines, what state did they get to when they stopped walking?	Made up; based on discussion in her social studies teaching methods course.
3	For both groups: 52 boys and 42 girls went to basketball camp. In order to play basketball, these kids needed to be split up into teams of five. How many teams of five would there be? Are there any left over kids? If so, what would you do with them? If each team got to play each other team 1 time, how many games would each team play?	Made up.
4	For both groups: This problem has to do with estimation and measurement. First of all I want each of you to estimate how many pencils tall you are. Remember, only estimate this to begin with--do not do the actual measurement. After each of you have done your estimation, help each other to actually measure how tall you are using the pencils. Do not use a standard measuring tool. Then after you have discovered how many pencils tall you are, measure the pencil with a ruler. Using this measurement, can you find out how tall you are? If you can, send me the results on all four of you! Make sure you tell me how tall the pencil was!	Made up; discussed in the math teaching methods course.
5	For both groups: Andrea turned on the radio at 6:00 A.M. and heard the temperature was 13 degrees. That night she heard that the temperature had risen 3 degrees each hour until 3:00 P.M., when the temperature was at its highest for the day. What was the high temperature that day?	Adapted from math teaching methods textbook.

Table 1 (continued)

Week	The Problems Sent	Sources Used
6	For Oregon: No problem sent to the Oregon group this week due to schedule conflicts.	
	For Virginia: Three children are collecting sea shells on the beach. Two of the children collect 42 shells each and the third child collected 35 shells. Did the children collect more than 100 shells in all? How many shells did they collect? The children's parents told them they could only bring 50.	Teacher manual from textbook.
7	For Oregon: Communication is important between space stations. A call between stations costs $5.00 for the first 3 minutes and $2.00 for each minute after that. What is the cost of a call that began at 7:35 and ended at 7:44?	Teacher manual from textbook.
	For Virginia: Miss Simon gave Steve $15.00 to spend at the fair. He bought cotton candy that cost $1.25 for himself and 2 friends. He also went on 3 rides that cost $.75 each. Admission to the fair was $1.50. How many more rides can he go on before he runs out of money?	Adapted from math teaching methods textbook.
8	For Oregon: No problem sent to the Oregon group this week due to schedule conflicts.	
	For Virginia: John has just finished reading a new story book. He read 30 pages a day for 9 days. How many pages did the story book have?	Made up.
9	For both groups: It's Thanksgiving and Big Dave sits down to eat dinner. Big Dave knows he can eat 50 ounces of food until he is full. Dave eats 13 ounces of Turkey, 8 ounces of mashed potatoes, 4 ounces of gravy, and 8 ounces of bread. For dessert, Dave can choose between 5 ounces of pecan pie, 5 ounces of pumpkin pie, and 7 ounces of cherry pie. If Big Dave wants to eat 2 pieces of pie, which 2 pieces does he have to eat if he does not want to go over 50 ounces of food?	Made up.
10	For Oregon: Miss Simon gave Steve $15.00 to spend at the fair. He bought cotton candy for himself and two friends. This cost him $1.25 for each friend. He also went on 3 rides that cost $.75 each. Admission to the fair was $1.50. How many more rides can he go on before he runs out of money?	Adapted from math teaching methods textbook.
	For Virginia: No problem sent to the Virginia kids this week to give them a chance to catch up.	

As the activity progressed, however, Chelsea began to get frustrated with the lack of success that her student groups were experiencing. She went back to using the commercial sources to locate problems because of her low self-confidence. Her problems were selected more for their simplicity than they were for their value in helping the children develop mathematical problem solving skills. This was most evident in week 8, when

Chelsea sent a traditional type of item found in many textbooks–it was a computation put to words requiring no reasoning to solve it (John has just finished reading a new story book. He read 30 pages a day for 9 days. How many pages did the story book have?).

Chelsea had a difficult time developing an understanding of the skill levels of her two student groups. She sent problems that the Oregon students said were too easy, but the Virginia students struggled with them week after week, despite being a year older. During the interviews, she repeatedly addressed the Virginia group's lack of success with her problems, indicating that a correct solution was the indicator of success. At one point she suggested that the fourth grade group was below grade level because they had yet to correctly solve a problem. She said she would feel better when the fourth graders actually computed a right answer.

Chelsea believed that part of the problem with the Virginia students was that they did not put forth their full effort while working with the problems. Even so, she still wanted to be able to tell them they solved a problem correctly. This is why she sent the computation to them, speculating they would be able to at least multiply. She recognized the poor quality of her problem selection, but was more interested in having the students get a correct answer than she was in helping them developing problem solving skills. Her analysis of her problem selection was right; the students solved the item correctly. Chelsea felt better as a result.

This particular item did not require the students to think or reason. They simply had to decide which operation to use and then apply the numbers. Chelsea may have believed it to be a real-life type of problem in some ways because she named a person and put it in a context kids understood–reading a book. However, she knew that the item was not an example of a good problem, based on the NCTM Standards. She felt it was more important for them to solve a problem correctly at that point than it was for her to make a good problem selection.

Just as she blamed her poor mathematics skills on her past teachers, Chelsea attributed the students' difficulties on their lack of effort rather than focusing on her inability to find items that were appropriate based on their skills. She knew that not all of her items involved qualities that would help her students develop problem solving skills, but she believed that they could not handle more difficult problems. She said, "I learned the difference between real problem solving and problems that are just adding and subtracting put to words.

However, I felt it was hard to use this [information] because the problem solving problems seemed to be harder [than what my student groups could do] and I wanted the kids to be successful." She thought that she might have been more successful in selecting good problems if she had been able to see the students as they worked with the items. She felt that watching them would have helped her learn the exact cause of their difficulties.

Early in the activity, Chelsea sent different problems to her third and fourth grade groups, with problems she perceived as more difficult going to the fourth graders. After several weeks of frustration, she began sending the problems that she had initially sent to her third graders–ones she considered to be easier–to her fourth grade group in an effort to have them find a correct solution. The items she sent to her fourth graders initially were forwarded to her third graders later in the activity. Chelsea perceived the skills of the third graders to be more advanced, and, in fact, these students did not experience the difficulties in solving the problems that the Virginia students encountered.

Problematic and positive interactions

The preservice teachers were asked to forward an interaction to me that they regarded as problematic, and specify a reason for their selection. Chelsea chose a message from the Virginia group that included comments from the classroom teacher. In the message, the teacher told Chelsea that the students did not have any idea what to solve at first, and then after she pointed them in the right direction, they still did not respond to the questions that Chelsea asked them. Chelsea explained why she chose this as problematic:

> I was really counting on my fourth graders being successful with this one since my third graders were so successful with it. I was very disappointed because I needed them to have one positive experience, as well as a positive experience for myself. I'm starting to feel like they may not even be putting their full effort towards these problems because they are not answering the questions I am asking them.

When this interaction was discussed further, Chelsea said that she sent this problem in hope that it would be one they could solve. Her third graders did not have any difficulty with it. It became apparent after more probing that there was a deeper reason for her selection of this item. Chelsea claimed, "I just want them to get one right. It [not being able to solve the problems] has been a negative experience for both me and for them, I think. Maybe I'm trying to send an easy one more for myself than for them." The student message was viewed as problematic, then, because the students did not solve it correctly. Chelsea's new challenge became finding a

problem for which the students were guaranteed of getting a correct answer. Chelsea struggled all semester with finding the level of her Virginia group–and her problematic interaction selection confirmed her indecision.

The positive interaction selected by Chelsea was a message written by her Oregon students. They told Chelsea that the problem was "just right" for them. Although Chelsea was better able to match her problems to the skill level of the Oregon students than she was for the Virginia students, this was a continual theme for her throughout the e-mail activity. Affirmation from the students regarding the level of her items was very important to her.

Authenticity

There were several elements of the e-mail activity that characterized it as authentic for Chelsea, based on the qualities discussed by Myers (1993). One of these items dealt with the perception of the activity as being genuine. On a continuum with contrived experiences at one end and real or genuine experiences at the other, Chelsea indicated her perception of the e-mail activity as feeling slightly less real to her than the practicum (see Figure 2).

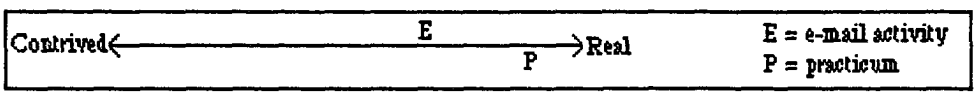

Figure 2. Chelsea's perceptions of the e-mail activity and the practicum experience as real activities.

She elaborated upon her ratings by saying that the e-mail activity was a good opportunity for her to work more with children in a school setting. She said that it provided her with the opportunity to write her own problems, where she did not have to rely on textbooks for her entire curriculum. It made her realize that she would have to provide different problems for her students to solve because it would be unlikely that they would all be performing at the same skill level. On the other hand, she felt that she did not get to control how much time the students spent working on the problems in the e-mail activity in the same way that she would be able to do in her own classroom, and she believed she would know the students better in a real situation. She claimed,

"This isn't working well for me [due to the lack of feedback from the Virginia group], but for the people that do get the feedback, I think this is great."

Chelsea believed that she learned from the e-mail activity, but that it would have been more real for her had her students provided her with detailed responses of the processes they used in solving the problems. Although she did not verbalize it, the Virginia group's lack of success seemed to contribute to her perception of the activity as not completely real. Chelsea was not adept at making special provisions based on the skill levels of the students, even though it was something likely to occur in a real classroom. As a result, the activity confirmed her doubts about her ability to teach mathematics.

Chelsea initially was very dissatisfied with the way the practicum was structured and with her experience in her school placement. The practicum was only seven weeks long, which was not enough for her to really gain an understanding of how mathematics and science are taught. She was frustrated with the lack of attention that her cooperating teacher showed her early on in her placement and with the feedback her university supervisor provided through the whole experience. In addition, she did not get to work with mathematics very much in the practicum. She said, "In comparison to my practicum, I received much more experience in math [through the e-mail activity] than I am receiving in math and science combined in my practicum. Most of the time I do not even observe math or science in my practicum. Overall, I have been very disappointed in it."

Despite these negative remarks, however, Chelsea's rating of the field experience indicated that it was a genuine experience for her, more than the e-mail activity. Chelsea said that the practicum felt real to her because she worked with actual children. There were real-life problems and situations that she needed to deal with beyond just the mathematics or science that she was there for–and that these elements were a part of teaching. Her cooperating teacher made a more positive impression on her during the last weeks of the field experience, and Chelsea felt that this also helped to make it more meaningful for her.

Chelsea's rating of the field experience was quite high, given the negative aspects she described. Even if she was not with the children for an extended time period, nor did she observe very much mathematics in the classroom, she still felt that it was a real experience. She worked directly with children and dealt with items

consistent with what she would encounter in her own classroom. Her rating of the e-mail activity in relation to her field experience demonstrated how important it was to her to have face-to-face contacts with children.

Being challenged and taking risks were other factors contributing to the authenticity of an activity (Myers, 1993). Chelsea believed she took lots of risks when selecting problems to send to her groups. In fact, she said, "Every time I send a problem to my fourth grade class, I think I'm taking a risk." She felt more confident about her work with the third grade group, but still admitted there was some anxiety there as well. She was never completely sure if the items she sent to either group were consistent with their abilities.

Chelsea felt that she could create problems to send that were of higher quality than what she found in commercial resources. Selecting already-made problems was a challenge for her since she did not have a lot of confidence in herself. She felt good about the items she created, however. She applied ideas discussed in the teaching methods courses so that she had some concept of what might be an appropriate type of problem to send. Chelsea started to see that problem solving involved more skills and thinking than what she initially believed it to involve.

The e-mail activity helped Chelsea realize that she did not have to rely on commercially-produced materials for teaching mathematics. She used the opportunity to create her own problems, based on her perceptions of what the children could solve. She was very pleased when she was able to match a problem to the skill levels of her student groups.

Although the e-mail activity was somewhat negative for Chelsea because of her struggles with her Virginia group, she still said that it was a good experience for her. The e-mail activity gave her an opportunity to work with older children than she had previously worked with; all of her practicum experiences had been with either kindergarten or first grade students. She also felt that the e-mail activity allowed her to see students' involvement with mathematics. Chelsea said that she did not observe very much mathematics in her practicum classroom. It was clear that the activity allowed her to grow in ways that would not have been possible in the field experience alone.

Overview

Chelsea felt that the e-mail activity helped her to learn several things. One was that it provided her the opportunity to learn how to use electronic mail. By the end of the semester, she felt very comfortable with the technology. She also felt that it was good to work with older children than she had been accustomed to working with. She felt that there were so many mathematical activities appropriate for this these more advanced skill levels as opposed to what would be suitable for the kindergarten children in her practicum.

Chelsea's experience with the e-mail activity may not have been as positive as some of the other preservice teachers' experiences. Her involvement was a continual struggle to try to match problems with the ability levels of her student groups. Although the problems that she sent were not always appropriate for the skill levels of her student groups, she felt that she gained experience in trying to target the needs of specific students. She developed several of her own problems. They did not involve as much reasoning as the problems sent by some of the other preservice teachers, but based on Chelsea's starting point and comfort level with mathematics, it showed that she experienced growth.

Although Chelsea felt that she developed an understanding of what the Oregon students could do mathematically, she said that the e-mail activity was one that caused her some anxiety. She felt that she did not have a good understanding of the mathematical skills of her student groups, although she speculated what the Virginia students were like: "The Virginia group is made up of poor readers. They have a short attention span. The problems [that I've been sending to them] maybe take more time than they're given. They don't go back and reread their work." Based on the comments provided by the classroom teacher at the Virginia site, these comments were fairly accurate. Even though she made these observations regarding the work habits and efforts of her Virginia group, she could not successfully translate this information into problems that they could solve.

Chelsea had a high level of mathematical anxiety, and she admitted that her anxiety level may affect her ability to teach mathematics to elementary children. Her anxiety seemed to surface in her involvement in the e-mail activity. She experienced a great deal of frustration trying to find problems appropriate for both of her student groups. She needed affirmation from the students that the items she was sending them were indeed at a good level–she continually struggled to find this level on her own. When she was unsuccessful in finding

appropriate problems after several weeks of the e-mail activity, Chelsea blamed the elementary students for their lack of effort, rather than trying to adapt her problems further to better meet their needs. Her lack of confidence in her ability to work with the children in a mathematical problem solving sense became more and more evident as the activity progressed.

Some of Chelsea's reactions toward both the e-mail activity and her field experience portrayed her as a pessimist or a complainer. Instead of focusing on the positive elements of the situations, she became frustrated when things did not go smoothly. It was possible that this was again due to her lack of self-confidence with respect to mathematics. Although Chelsea said that she wanted to provide a better mathematics background for her students than what she received as a student, her reaction to the e-mail activity showed that her lack of comfort may inhibit her success in doing so.

Jessica

Personal Background

Jessica, an Early Childhood Education major who wanted to teach kindergarten, was another of the preservice teachers with a high degree of anxiety toward mathematics. Her MARS score at the beginning of the semester was 306, slightly lower than that of Chelsea, but a score still indicative of someone fearful of mathematics. Jessica agreed that the score was an accurate depiction of how she felt about mathematics. She had been in advanced classes through seventh grade, and mathematics came easily to her at that time in her life. In high school, however, she had a difficult time with her mathematics coursework. She attributed her lack of understanding to poor teachers.

Jessica recognized her anxiety toward mathematics and knew that it may impact her teaching performance; she worried about teaching mathematics. She felt that she did not have good examples of mathematics teachers when she was a student, and that this might affect her own teaching practices negatively. She felt confident that she understood the mathematics content at the levels she would teach–she just did not feel completely comfortable trying to teach young children to learn mathematics.

When she took the MARS test at the end of the semester, Jessica's score went down to 227, a decrease of 79 points. When asked about the change, Jessica said that she definitely felt less anxiety toward mathematics than she had prior to the course. She suggested that the manipulative-based approach used in the mathematics teaching methods course helped her not only to feel comfortable teaching mathematics, but it also helped her to understand mathematical concepts that she had previously not understood very well. Mathematics had more meaning to her than it had before she enrolled in the methods course.

Jessica's renewed confidence level was impacted not only by the teaching approach used in the mathematics teaching methods course and in her involvement in the e-mail activity, but also by her success in developing quality mathematics teaching materials for the course. She created a mathematics learning center that she used with the elementary students in her practicum. The learning center included a variety of manipulative-based mathematical activities that centered around apples. The activities were appropriate for the kindergartners in her practicum, and the center was designed to help stimulate the childrens' interest in mathematical concepts. The children enjoyed working with the learning center so much that her cooperating teacher decided to use more learning centers in her classroom. Jessica felt that centers were a nice approach to teaching mathematics to students, especially at young age levels, and she felt very good that she was able to influence her cooperating teacher of the value of centers. At the end of the semester, she was less fearful of teaching mathematics and even felt she had several strengths in the area that would help children learn (using manipulatives, linking mathematics to literature, and creating meaningful mathematics learning centers).

The student groups

Jessica was paired with students at the same two sites as Chelsea: third graders from Oregon and fourth graders from Virginia. At the beginning of the activity, Jessica felt no more informed about what to expect from her students than Chelsea did. She thought that the students should be able to perform basic mathematical operations, relate shapes, and do some fundamental geometry. Jessica realized her lack of knowledge with respect to what typical third and fourth graders could do. She was not sure if she would be able to send appropriate problems to her student groups. She said, "I don't feel really confident about this right now. I feel that I learn by doing. I can look at the feedback that the students provide, and then adapt each time to send a

better problem." Despite her low confidence level, she felt that she would gain an understanding of their skills as she communicated with her student groups.

When Jessica first learned of the e-mail activity requirement, she felt it would be a good opportunity for her to learn about teaching mathematical problem solving. Although she became anxious after problem solving was discussed in class, she realized that the e-mail activity was a learning opportunity and decided that she could learn and grow from the mistakes that she made. Rather than let the activity intimidate her, she decided to take a positive approach to the activity.

Jessica's impression of the Virginia group, on the whole, was similar to what Chelsea shared. Based on what the fourth graders wrote in messages to Jessica, she got the impression that "they had really bad attitudes". She said, "you can tell they don't like math." Jessica felt that the classroom teacher had to really push the students hard to get them to solve the problems that were sent. Jessica suggested that if the fourth graders typed their own responses into the computer (the teacher collected their written responses and then typed those messages to the college students), that they would probably take the activity more seriously and try harder.

After ten weeks of communications with the Virginia group, Jessica felt that their mathematical problem solving skills were improving, partly due to her feedback. She said that several weeks into the activity, she began providing hints to them along with her communications. She felt that this practice helped them formulate a plan for solving the problem. Even so, she believed that these students did not put forth enough effort in writing their responses for her to develop a good understanding of their skills and capabilities. She tried to include problems that were about issues and ideas that they could relate to, but even so they did not always write extensively. Although Jessica felt that she was taking extra steps to provide meaningful experiences for her student groups, she did not feel that they were equally committed to the activity.

Unlike the Virginia group, Jessica felt that the third graders from Oregon had well-developed problem solving skills for their age. They used effective approaches to the problems. Jessica said, "They always seem really positive about their responses....They always tell me how they do it." This was the key element missing from the Virginia communications. The Oregon group, according to Jessica, always described the process that

they used to solve the problem and this helped her choose other items that were appropriate for them to solve. She had to guess a lot more with the Virginia group.

After several messages had been exchanged, Jessica felt that her problems had been at least fairly appropriate for her groups. She expressed some concern about her Virginia group, however, due once again to their lack of communication. "I'm having a hard time because they say the problem was easy or hard, but they sometimes don't tell me how they worked on it." That made it difficult for Jessica to determine the reason the problem was too easy or too hard and therefore made it troublesome to choose new problems for them. The Virginia *teacher* provided feedback, and Jessica found those comments to be helpful. Nevertheless, she yearned for more student feedback as well.

Jessica had some doubts about how to respond when the elementary kids sent back wrong answers to problems. She said that it was difficult to reply since she was not right there when the students solved the problem, and also since time passed between when students solved the problem and when she provided feedback to them. A classroom teacher could supply more immediate feedback than what the preservice teachers could provide in the e-mail activity. Jessica felt that this aspect of the e-mail activity was one of the limitations of using the telecommunications medium.

Problem selection

A good mathematical problem defined by Jessica was one where students needed to reason in order to find an answer. She believed they should be able to use manipulatives to help them solve the problem and they should feel like they accomplished something after working on it. Problems with real world types of topics like money were good, too, according to Jessica. The problems that Jessica sent through the semester are listed in Table 2.

Jessica did not use many different sources in selecting the problems to use with her student groups. She primarily used the TOPS Problem Solving Decks as a resource, and she sent the same problems to both of her student groups. It actually appeared that Jessica located a variety of problems from the TOPS decks early in the activity and saved them for later rather than evaluating the students' skill levels weekly and then searching for an appropriate problem. Near the end of the e-mail activity, it seemed that Jessica began to lose interest in

Table 2

Jessica's Weekly Problem Selections

Week	The Problems Sent	Sources Used
1	For both groups: Stewart has a collection of baseball cards. If he puts them in piles of 2, he has 1 left over. He also has 1 left over if he puts them in piles of 3 or 4. In piles of 7, he has none left over. What is the smallest number of cards he could have?	Math textbook
2	For both groups: How many ways can you use dimes, nickels, and pennies to make $0.20? Make a list to show me the different ways you came up with.	TOPS Problem Solving Deck
3	For Oregon: Pancake recipe: 2 cups pancake mix, 1 cup water, 1 egg. This recipe makes 12 medium pancakes. I am expecting 18 guests for breakfast in the morning, and they will each eat two medium sized pancakes. How should I change the recipe to make enough pancakes for my guests?	TOPS Problem Solving Deck, then changed
	For Virginia: Pancake recipe: 2 cups pancake mix, 1 cup water, 1 egg. This recipe makes 12 medium pancakes. If I am expecting guests for breakfast in the morning and I want to make 36 medium pancakes, how would the measurements of the recipe change?	
4	For both groups: How many pages are in the book? Clue 1: There are more than 100 pages. Clue 2: There are fewer than 500 pages. Clue 3: All three digits in the number are the same. Clue 4: The sum of the three digits is 6.	TOPS Problem Solving Deck
5	For both groups: June is taller than Rose. Rose is taller than Amy. Their heights are 135 cm, 142 cm, and 127 cm. How tall is Rose?	TOPS Problem Solving Deck
6	For Oregon: No problem sent to the Oregon group this week due to schedule conflicts.	
	For Virginia: Would you rather have 50 nickels or 30 dimes? Why?	TOPS Problem Solving Deck
7	For Oregon: Would you rather have 50 nickels or 30 dimes? Why?	TOPS Problem Solving Deck
	For Virginia: They solved a problem that was not one sent by Jessica, so Jessica re-sent the problem dealing with the dimes and nickels.	
8	For Oregon: No problem sent to the Oregon group this week due to schedule conflicts.	
	For Virginia: How many ways can you put 11 marbles into 2 cans? Make a list. Remember you do not have to figure this in your head, you can use counters or you can really use marbles and 2 cans.	TOPS Problem Solving Deck

Table 2 (continued)

Week	The Problems Sent	Sources Used
9	For Oregon: How many ways can you put 11 marbles into 2 cans? Make a list.	Borrowed the problem from another classmate.
	For Virginia: Mandy forgot the names of her friend's kitten, dog, and parakeet. She knows the pet's names are Queen, Duke, and Angel. Help Mandy decide which name goes with which pet. Clue 1: Queen is smaller than the dog. Clue 2: The kitten is younger than Queen. Clue 3: The kitten is older than Angel.	Borrowed the problem from another classmate.
10	For Oregon: Mandy forgot the names of her friend's kitten, dog, and parakeet. She knows the pet's names are Queen, Duke, and Angel. Help Mandy decide which name goes with which pet. Clue 1: Queen is smaller than the dog. Clue 2: The kitten is younger than Queen. Clue 3: The kitten is older than Angel.	Borrowed the problem from another classmate.
	For Virginia: No problem sent to Virginia so that they could catch up.	

locating good problems to send to her groups since she just exchanged problems with another mathematics teaching methods student. She no longer searched through different materials to find suitable problems. It seemed that she began to maintain her involvement in the activity to satisfy the requirements of the course rather than look at it as an opportunity for further growth.

Although her initial items addressed the qualities of good problems that she defined prior to the start of the e-mail activity, the amount of reasoning needed for the last half of the problems that were sent was minimal in several cases. Jessica asked the students to explain why they would prefer to have 50 nickels or 30 dimes, but by the third and fourth grade level, little reasoning was needed to make the choice. Similarly, finding the possible combinations that would split eleven marbles into two cans at those levels required little thought and was rather a series of additions. Like Chelsea, however, Jessica struggled to find appropriate problems for her groups–especially the Virginia group–so it seemed as if reasoning took a back seat to finding something that the students could actually solve.

Jessica said that she started to provide hints to the students after several weeks of struggles, so that they would have some direction in the activity. In examining the problems in Table 2, however, there was very little

evidence that this was occurring to any great extent. In the second week, she told the students to make a list, and in the eighth week, she said that they could use counters to help them solve the problem. Her other items included no additional help when they were first sent to the groups. After the students sent back an incorrect solution, she provided them with more feedback to help them try again, but initially they were left to formulate a strategy on their own.

Problematic and positive interactions

Jessica selected one of the messages from the Virginia group as problematic. This particular message was in response to an item asking the students to find as many ways to make twenty cents as they could. Jessica was disappointed with the number of combinations they found. The students listed only one combination involving sets of coins that were not all of the same denomination. The teacher had to suggest the use of manipulatives; Jessica was disappointed that the children did not think of using them on their own. She decided that maybe the problem was just too difficult for them. By third and fourth grade, the students should have been able to come up with more combinations that addressed Jessica's requirements. It was possible that they did not completely understand what Jessica wanted from them.

This problematic selection was an interesting contrast to what Jessica chose as her positive interaction. The positive message she selected was from the Oregon group, in response to the same coin problem described above. Here is how Jessica felt when she read what they wrote:

> The group responded to this problem with the correct answer and also told me how they came up with the answer. Also included in their response was their feelings on how difficult or easy the problem was. They also answered my personal questions and wrote other things besides the answer to the problem....After reading this response I felt we made a connection. They knew what I was asking, and gave me the information I needed!

The nature of the communication between Jessica and the elementary students went beyond merely their answer to the problem, and this personal communication was very important to her.

Authenticity

In terms of rating the e-mail activity on a continuum from a contrived to a real experience, Jessica judged it to be right between these two extremes. She had mixed feelings about the activity. The e-mail activity made her realize how difficult it was to work with students, especially when they did not understand

what to do. She realized that helping children to develop mathematical problem solving skills was not an easy task. On the other hand, Jessica said that the turn-around time for messages made it difficult for her and for her student groups to grow. She felt that there was little closure on the problems because of the long turn-around time. She believed that the elementary students did not get enough reinforcement or feedback to help them effectively develop problem solving skills. Figure 3 depicts Jessica's rating of both the e-mail activity and her field experience.

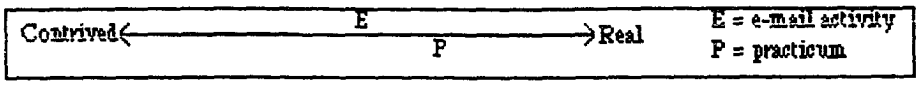

Figure 3. Jessica's perceptions of the e-mail activity and the practicum experience as real activities.

Jessica rated her practicum experience higher than her participation in the e-mail activity. What made the field experience more real to her than the e-mail activity was that she actually got to interact with the kids when she was at the school site. More than just learning about teaching in a course, or even through e-mail, she got to have face-to-face interactions with children. In the e-mail activity, she questioned whether the Virginia group put forth a great amount of effort in solving her problems or responding to her messages. In the practicum, she could see exactly what the students did and ask for more detail if not enough was provided.

The reason the field experience was not rated as even more real was that Jessica did not observe the practicum students doing very much mathematics. The cooperating teacher claimed to provide mathematics instruction every day, but Jessica questioned some of the activities as being "math" activities. She felt that even in a kindergarten classroom, there was room for much more mathematics than what she was seeing. In fact, Jessica hesitated for a long time when she was asked what she learned from her practicum experience. She enjoyed working with the children at the school but felt she did not have much opportunity to prepare herself to teach mathematics based on time spent at the school site.

The face-to-face interactions of the practicum experience were very important to Jessica, even if they were not necessarily in a mathematics context. This became evident when she was asked to compare the relationship she had with her e-mail groups to that of her practicum students. Her response:

> I don't feel like I have a relationship with the e-mail groups. I think we just write back and forth. I don't really know anything about *them*, other than really small things....But in the practicum, I'm actually there with them and I know how they act. I can form more of a relationship that way.

Jessica felt that the e-mail activity could not provide the kind of interaction that would really help her to understand the way kids learn. She said, "Being with them, you can see what kinds of skills they have rather than going through e-mail where you pretty much have to just go by what they say to you. If they [the children in the e-mail activity] can't explain it to you, then you don't know [what they did or what they understood]." It was evident that this personal element was very important to Jessica, and that an electronic experience was just not be the same type of quality experience for her as a face-to-face setting would be. Her realness ratings reflected her opinion of face-to-face contact with children.

The idea of the realness of the e-mail activity, overall, for Jessica was similar to that of Chelsea when compared to the rating of the field experience. Both ratings were lower for Jessica than they were for the other case study participants, however. For Jessica to rate something as being a more real experience, she would need to have control over what transpired--and this was not completely possible in either the e-mail activity or the field experience. She needed to see things directly rather than speculate about what happened. For someone like Jessica, an electronic activity may possibly never be considered to be a genuine experience as a result.

Realness was only one of the categories defined by Myers. Risk taking and making a difference were the other two. Jessica felt that the activity helped her become more familiar with using electronic mail and in writing problems, and she believed that it gave her an opportunity to learn about children from areas of the country that she knew little about. She recognized that since she was not there to help the students work through the problems, she needed to provide them with some direction and focus to get them started. Despite this recognition, she really did not provide much assistance for her groups when solving problems.

It was challenging for the Virginia group to explain to Jessica what they did when solving problems, and this made it more difficult for her to communicate with them. Jessica believed that the students might have better mathematical problem solving skills than they could effectively communicate to her in their e-mail messages. She thought that if she could ask them follow-up questions or see the materials they used to

construct their solutions, that she could better assess what they knew. She was frustrated at times, like Chelsea, with the effort put forth by this group.

Although there were negative aspects of the e-mail activity, Jessica still felt that her involvement went well. She felt that the e-mail activity helped her to try to come up with problems that were appropriate for the students she worked with. Because she worked with two groups of students, she felt that she gained an understanding of the variety of skill levels that could be present even among children of similar ages.

Overview

Although Jessica had a high level of mathematical anxiety, she hid it much more than Chelsea. She experienced what she felt was lots of success in the mathematics teaching methods course because she felt that the hands-on approach helped her to understand the mathematical content better than she had understood it prior to the course. The teaching materials she produced for the course and for her practicum were of very high quality, and it seemed that she was able to overcome some of the anxiety that she had experienced early on in the semester. Jessica seemed to be a true teacher in the sense that she wanted to learn as much as she could so that she could be effective with the children who would someday be in her classroom. She did not want her own anxieties to hold her or her students back.

She couldn't completely hide her anxieties, though. Responding to wrong answers made Jessica very uncomfortable. She did not know what to say without making the children feel badly for making an error; she wanted to be positive but also did not want to just ignore a wrong answer. For the first few weeks, she discussed alternate ways of approaching the problem with the children, but gave students positive feedback for their efforts.

Several weeks into the activity, Jessica seemed to become more comfortable with her role in responding when wrong answers were given. She started providing suggestions for how the students might progress, and asked them to give the problem another try. To her, this was a very risky thing to try. She commented that if she asked them to try the problem again, that the students might get serious about solving it.

Jessica felt that the time and effort put into the e-mail activity helped to prepare her for teaching mathematical problem solving skills to students. However, there were several aspects of the activity that were

troublesome for Jessica. At first, Jessica's biggest frustration with the e-mail activity stemmed from not being able to send appropriate problems to her student groups. After she adjusted to the students and was better able to meet their needs, Jessica's comments shifted to the structure of the e-mail activity being limiting. She felt that the students would see expanded benefits if there were more frequent communications between them and her. Jessica believed that the design of the e-mail activity did not allow for closure on the problems. She really wanted to be with the children to watch them solve the problems so that she could develop a better understanding of their thinking process.

Jessica's biggest critical remarks were derived from her experiences with the Virginia group of students. Jessica felt that she put forth much effort in helping them develop their mathematical problem solving skills. She found her efforts unrewarded since the students did not go back to re-work the problem. Despite the difficulties identified by Jessica, she felt good about her participation overall.

Emily

Personal background

Of the interviewed preservice teachers with high mathematics anxiety levels, Emily was the most verbal in the mathematics teaching methods class. A double major in Elementary Education and Special Education, Emily wanted to teach upper-elementary aged children upon graduation. Her initial score on the MARS instrument was 296, and her score increased to 324 when she completed the instrument for the second time. This twenty-eight point increase was slightly more than the average decrease for the whole class and seemed somewhat inconsistent with her stated improved confidence levels with respect to mathematics. Emily felt that she was more honest in completing the instrument the second time. She felt more comfortable with mathematics and less intimidated by the subject at the completion of the mathematics teaching methods course although her MARS score did not reflect this change.

Like Chelsea and Jessica, Emily agreed that, in general, her MARS scores accurately depicted her attitude and anxiety level toward mathematics. She said that she never had any trouble with mathematics until eighth grade; in fact, she was in the high mathematics group in grade school and through seventh grade.

Algebra was a turning point for Emily, however. After that, "my heart beat faster when I heard the word 'math'." Her eighth grade and high school mathematics teachers could not explain things to her so that she could understand the material. "If I didn't understand something, they couldn't find any other ways to explain it to me. It [mathematics] was like a brick wall that I couldn't get over."

Emily's mathematical struggles did not stop in high school. She enrolled in the college algebra course at the university and failed it despite having a tutor to help her understand the concepts. Rather than taking the same course again, Emily decided to enroll in the mathematics for elementary teachers course. She found much more success in this course than she had in algebra. The instructor employed many methods of teaching concepts; she found ways to make ideas understandable for Emily. Emily enjoyed the course as a result.

Emily's venture into teaching was an interesting one. She said that she hated school until fifth grade when she had a teacher who made her feel good about being there. Prior to that, she would cry and get sick because she did not want to go to school. She was afraid of strictness because of a control issue that occurred in first grade. In addition, Emily said that she was not a good student in elementary school. Teachers perceived that she was unable to do things. The fifth grade teacher had a big impact on Emily because of her belief in Emily's abilities. The teacher was able to turn things around for her. It was Emily's goal to be the same type of role model and motivator.

Emily felt that her negative attitude toward mathematics would definitely influence the way she taught this subject to her future students. Because of her negative experiences, she was motivated to think about teaching mathematical content in ways reaching many learning styles. She felt that she could relate to the children's struggles; she wanted to be able to help them avoid the barriers that she encountered in her own mathematics experiences. Her negative experiences made her realize how awful it was to be confused in a mathematical environment.

At the beginning of the semester, Emily said she was concerned about having to teach mathematics, especially problem solving. She thought about sending her students to another teacher for their mathematics instruction. Emily said, "I know I should be teaching it, but deep down I really don't want to." She knew of the impact her attitude could have on her students later in their lives--and she knew that she did not want to

penalize them because of her own fears. She wanted to provide an environment that would help children have a better attitude than what she had, but she was not sure that she was able to do this herself. As she gained more experience working with children in mathematical contexts, she became less intimidated by the subject. By the end of the semester, she felt comfortable teaching mathematical content.

The student groups

Emily worked with fifth graders from Alaska and New Jersey throughout the semester in the e-mail activity. The Alaska students had participated in the e-mail activity the prior year as fourth graders; the New Jersey group was new to the experience. Emily speculated that these students would probably be fairly good at problem solving and critical thinking--otherwise their teachers would not have committed to participating in the activity. In terms of specific mathematics abilities, Emily thought that the students should be able to perform the basic operations well and comfortably, and that they should be able to work with fractions.

At the end of the e-mail activity, Emily's predictions were confirmed. She discovered that the students had good problem solving skills, which were enhanced by the items she sent to them. Their mathematical skills were consistent with what she believed they could do. She felt that she effectively selected problems that expanded upon activities they did in their regular mathematics curriculum.

When Emily first found out about the e-mail activity requirement, she was really nervous about participating. She said that she was afraid of computers and e-mail because of her inexperience with the technology. One of her friends began student teaching in Texas during the semester, however, and they began sending e-mail to each other on a daily basis. By the time the e-mail activity with the elementary students commenced, sending and receiving e-mail messages was no longer a concern for Emily.

Although she felt comfortable using electronic mail by the time the e-mail activity began, Emily felt that interpreting the messages from her student groups might be difficult for her. She thought that the student responses may not accurately depict their actual problem solving process or their reactions to the problem. She believed that it would be her responsibility to try to piece together what the students wrote in order to develop a good understanding of the process they used. She felt that it would be difficult for her to provide good feedback to her students without this understanding.

Problem selection

Selecting appropriate problems was one of the biggest challenges of the e-mail activity identified by Emily. She indicated that choosing activities appropriate for a specific grade level was always problematic for her in all content areas; she did not feel that she had a good understanding of the kinds of things children could do at different grade levels yet. To help make problem selection for her e-mail groups, she spent time looking at different fourth and fifth grade mathematics resources to get a better idea of what was normally covered in those grade levels. She felt that the e-mail activity would help her learn what would be appropriate because of the students' feedback.

In her initial interview, Emily indicated that appropriate problems were those that forced children to think, those that took some time to solve, and those that had more than one correct answer. Problems such as these were not ones that Emily would have enjoyed solving when she was in school. "I hated story problems when I was in school, and I probably would have preferred getting a basic computation problem rather than a more involved problem. But these basic problems won't help learners grow." Upon examination of the problems that Emily sent to her groups, it was evident that the items she selected addressed her identified characteristics of good problems, especially after the first three weeks. The problems she selected to send to her student groups, as well as the sources used in selecting problems, are shown in Table 3.

During the fourth week of the e-mail activity, Emily began creating her own problems instead of using commercially packaged resources. At first, these problems were similar to items discussed in the mathematics teaching methods class or included on the Problem Set that the preservice teachers completed early in the semester. As the e-mail activity progressed, Emily began creating unique problems to send to her groups. She recognized that she was sending appropriate materials when her students responded positively regarding what she sent to them. She needed this affirmation from the students to develop confidence in herself. She said, "I feel more confident about it [writing my own problems] since I know more of what they [the students] can do." She even began writing items that had more than one correct answer despite her lack of exposure to this type of problem as a student.

Table 3

Emily's Weekly Problem Selections

Week	The Problems Sent	Sources Used
1	For Alaska: Can you find the number I am thinking of? The number is less than 500; All three digits are odd; All three digits are different; The sum of the digits is 13; The product of the digits is greater than 30; The number is not divisible by 5. For New Jersey: No problem was sent this week due to a schedule conflict with the New Jersey site.	TOPS Problem Solving Deck
2	For both groups: Imagine that you work in a nice restaurant. Your goal is to wash as many dishes as possible in a short amount of time. You earn 1 cent for each dish you wash and you lose 5 cents for each dish you break. You made 45 cents after breaking 3 dishes. How many dishes did you wash?	TOPS Problem Solving Deck, then altered
3	For both groups: There are 6 telephone poles on my street. The poles are 200 feet apart. How many feet of wire are needed to connect the poles?	TOPS Problem Solving Deck, then adapted
4	For both groups: First of all, estimate how long it takes a person to ride one mile on a bicycle. Now find out how far it is from your town to Ames, Iowa. How long would it take you to ride a bicycle from your town to mine (Ames)? Remember, you will probably have to stop to eat and sleep. You may stop to sleep and eat for as long as you wish, just make sure you include these things in your answer.	Made up
5	For Alaska: I want you to pretend that you are going to remodel your classroom. You have decided that the first thing you need to do is put new wallpaper up. How much wall-paper will you need? (When measuring your walls you may need to do some estimating. It may be unsafe to use a ladder for measuring all the way up to the ceiling.) Now you have decided to get new carpet for your classroom. How much carpet do you need? Take a vote to see what color you will choose. Since I have never seen your classroom, I don't know how big it is. Make sure you include the dimensions of your classroom in your answer. For New Jersey: No problem was sent this week due to a schedule conflict with the New Jersey site.	Made up. Was modeled after similar problems.
6	For both groups: Imagine that you are having a family reunion and you are in charge of providing desert for everyone. You are told that there will be 45 people there. You decide to serve chocolate cream pie. You bake 9 pies and cut them each into five pieces. Suddenly you find out that 12 more people are coming. Do you have enough pie? If not, what are you going to do? You want to avoid baking another pie.	Made up.

Table 3 (continued)

Week	The Problems Sent	Sources Used
7	For both groups: Go outside and have one of your group members run one lap around your entire playground. Time the person as they run around. Go back inside and record his/her time. Now I want you to estimate how long you think it would take for the same person to run around the playground 2 times, 3 times, 4 times, 5 times, 6 times, 7 times, 8 times, 9 times, and 10 times. You may want to make a chart. Do you think it will take the same amount of time for the person to run the tenth lap as it did to run the first lap? Will it take less time? Will it take more time? Justify your answer.	Made up.
8	For Alaska: Imagine that the 4 of you are going on a 2 week camping trip. You decide to drive, even though the campground is far away. Use your imagination and pretend you are all old enough to drive. The speed limit on the highway you are taking is 60 miles per hour. You start off on a Monday morning with Emily driving. Emily drives for 2 hours and then Jeremy decides to drive. Jeremy drives for 3 hours. Now you are getting hungry so you stop to eat. This takes 1 hour. You start off again with Amy driving. She drives for 4 hours and then gets tired. Cody takes over driving for 3 hours. Everyone is hungry and tired, so you stop for 2 hours to eat and rest. When you leave the rest area, Emily drives again. After driving for 2 hours, she pulls into the campground. How many miles did you travel? For New Jersey: No problem was sent this week due to a schedule conflict with the New Jersey site.	Made up.
9	For both groups: Imagine that you are in charge of cooking Thanksgiving dinner. You decide to spend the morning making the stuffing for the turkey. Here are the ingredients for 1 batch of stuffing: 3 1/2 cups of bread (cut in cubes), 1 1/4 cups of water, 2 teaspoons of butter, 1/4 cup of pork sausage, 1/2 cup of onions, 1/2 cup green peppers, 1/4 cup of celery, 2 tablespoons of vegetable oil. You are planning on having a large group of people for Thanksgiving dinner, so you will need a lot more than 1 batch. You will need 6 batches. How much of each ingredient will you need?	Made up.
10	For both groups: An ice cream store advertises that it has the greatest number of flavors of ice cream. If you add the tens digit and the ones digit of the number, you get 12, and if you subtract the tens digit from the ones digit, you get 2. How many different flavors does the store have?	TOPS deck, then altered.

Emily was willing to send open-ended problems to help her understand more about the problem solving capabilities of her student groups. She was conscious about trying to include realistic situations that would be interesting to the students. She said that she tried to consider the students' perspective when writing problems. She was aware of how difficult it could be for them to try to interpret a problem written by someone who was not there to explain what was meant.

Providing good feedback to the elementary children was not one of Emily's strong points. She included lots of personal communication in her messages and the problems that she sent to her groups were interesting and involved. However, her feedback did little to reinforce the processes used by the children. Emily did not go back and reinforce their processes or expand upon why their solution was correct. It was almost as if she had decided that once the problem was solved once, it was time to move on to the next one.

Problematic and positive interactions

The e-mail activity was going well enough for Emily that she had difficulty selecting a problematic interaction. What she chose was part of a message written by her Alaska group. The students' response was, "Answer--we knew (Actually, Mrs. G helped us.). It had to be bigger than 45, because we had to subtract 15 to make 45." Emily chose this message because she thought the problem must have been too difficult for the students since they had to get help from their teacher. She did not think that getting help from the teacher was necessarily bad. Out of all of the interactions that she had with her student groups, however, this was what she felt was the most problematic interaction. The fact that Emily had a difficult time selecting something showed that she felt things had been going pretty smoothly overall.

The positive interaction that Emily shared was also from her Alaska group. The students wrote in one of their messages, "P.S. the problem was the perfect level and it made us think!". This was positive for Emily because the students did not find the problem too hard or too easy, and they were challenged to come up with a solution. She said that this message made her feel more confident that the problems she was sending to her groups were appropriate for them. She also thought this response was positive because it indicated that the elementary students were aware enough of their problem solving skills to know that they were capable of solving something where an answer was not immediately apparent.

Authenticity

Emily perceived the e-mail activity to be quite real and genuine, and her rating reflected that belief (see Figure 4). She said:

> I find that I enjoy this. When we first started doing this [the e-mail activity], like the first week, I kind of dreaded it and I kept putting it off thinking, oh, I have to find a problem. Now that I'm making up my own problems, I feel that it's really going to help me when I'm in my own classroom and have to make up problems. I know that I'm going to have to make up a lot of my own problems because the ones in the textbooks are not good in terms of problem solving. So I think it's helping me a lot in terms of real situations.

She also said, in a later interview, that the activity helped her become more comfortable with teaching mathematics and mathematical problem solving. Emily explained, "I'm still a bit anxious about teaching problem solving, but I'm better. I think it's fun now." At the conclusion of the activity, Emily identified writing problems as one of the strengths that she could bring into her mathematics teaching. Since Emily had a large amount of mathematics anxiety, this was a significant statement. She recognized that despite some lingering doubts about her ability to teach mathematics, she had something positive to offer to students.

Figure 4. Emily's perceptions of the e-mail activity and the practicum experience as real activities.

Emily felt that one of the drawbacks of the e-mail activity was that she could not actually see what the children were doing as they solved problems. As a result, she was not certain if she completely understood their processes. When she was in her practicum classroom, she could listen to the children talk to help her gain a better understanding of their thinking. She could see the variety of skill levels within one classroom. In addition, she had the opportunity to work with a younger group of students in her field experience than would be possible in an e-mail type of activity–and she felt this was helpful.

When Emily rated her practicum for realness, she rated it at the same location on the continuum as she rated the e-mail activity. She said that the experience felt real to her because she was very involved with the children when she was at the school. Her cooperating teacher helped her to develop skills in relating literature to

mathematics and in using a learning center approach to teaching. The students she worked with in her practicum were involved with a manipulative-based, discovery-oriented mathematics curriculum called dap (Developmental Activities Program). This program was a hands-on, individualized mathematics and science program based primarily on Piaget's research on children's thinking (Phillips & Phillips, 1987). The program was one where the children explored with objects and the teacher observed, questioned, and encouraged the students to construct their own arrangements, groupings, or patterns. Emily felt it was positive for her to experience this program. Despite how positive the practicum was for Emily, she did not rate the experience higher because she felt that the time frame was too short for her to really get to know the children in her classroom. Also, schedule conflicts prevented Emily from meeting the children until her third visit to the school.

There were benefits to both experiences for Emily. She felt that there was less risk in trying out problems in the e-mail environment. She said, "I didn't have to deal with the frustrations of the students [if they didn't understand the problem] like I would have to do if I were right there. It is easier to try out new things this way. I think I was more likely to try something new or different this way than I would be in a real class." She thought she would have been more nervous if she had been in a fifth grade classroom for her practicum and gave these same problems to those students to solve. The practicum provided her with first-hand exposure to students as they learned mathematics.

Overview

Emily's case was an interesting one to follow because of her problem selection. She had a high level of mathematical anxiety, and was aware that her attitude may influence her approach to teaching the subject. However, she appeared very confident in herself and in her abilities to interact with her student groups. Despite failing grades in mathematics courses at the high school and university level, Emily created mathematical problems for her student groups that challenged them to think. She tried very hard to create problems that were open-ended or that had more than one answer so that the students would be encouraged to come up with unique methods of solving the problem. It was likely that the structure of the e-mail activity encouraged Emily to send mathematical problems that she would not have used in a real classroom.

Several of the problems that she sent were ones where the students really could *not* have an incorrect response. For example, the pie problem asking the students to figure out how to slice the pies differently could be accomplished in a variety of ways. Student estimates of the time taken to run laps around the playground also could not be considered to be incorrect, either, to an extent. Emily created situations where the students could not fail. If the students could not solve a problem incorrectly, then she did not have to provide negative feedback to her student groups. The problems that she selected, then, may have been a manifestation of her insecurities about mathematics. Regardless of whether her problem selection was intentionally set up so that the students were guaranteed success, Emily's confidence soared in this activity.

Emily felt that one of her strengths in the e-mail activity was her ability to relate to the students. She felt that she was perceptive in understanding what they meant and did, even when they did not directly tell her. She enjoyed the interactions with the students, and found that the information they told her gave her a better understanding of what children of that age may be like. She felt that the communications part of the e-mail activity helped to prepare her for teaching.

By the end of the semester, Emily definitely had a higher comfort level in terms of teaching mathematics than she had at the beginning of the semester. She claimed that she still felt at least somewhat anxious in a mathematics environment, however, especially when working with older students. She felt fairly confident that she could work effectively with students in grades two through four, but that older and younger kids would be more difficult for her to deal with. She felt that reading ability influenced the kinds of mathematical activities that could be done with younger kids, and the older students had more variation in skill levels. Although she perceived an improvement of her attitude about teaching mathematics during the semester, Emily still showed a high level of mathematical anxiety at the completion of the course.

Lori

Personal background

Lori had a lot of confidence in her mathematical abilities. Lori's initial score on the MARS was 132, and it was reduced even further to 108 by the end of the semester. Considering that the minimum possible score

was 98, it was evident that Lori did not feel intimidated by mathematics. Lori said that she had always been good at mathematics, and that the low anxiety score reflected her comfort level with the subject. She enjoyed mathematics and did well in the courses that she took. Her high school mathematics teacher helped give her confidence in her ability. Unlike Jessica who felt satisfied knowing just enough mathematics to work with young students, Lori felt that one of her strengths would be her solid knowledge base. Lori was an Early Childhood Education major with a Special Education endorsement and hoped to soon teach at the pre-kindergarten or kindergarten level.

Teaching appealed to Lori because of the caring and nurturing aspect involved in working with children. She wanted to work with kids to help empower them and make them independent learners, mostly because she felt that these were qualities missing from her own education. As a young student, she was instructed to sit at her desk and be good, "as all girls should." Since Lori was shy–and also because she interpreted things literally, this is what she did. As a result, it was difficult for her to participate verbally in class discussions, even as a college student.

The student groups

Lori was paired with a fourth grade group from a small, private Pennsylvania school and a group of fifth grade students from a more traditional school setting in Alaska. The Alaska group was from the same classroom as Emily's students. The teacher of the Pennsylvania fourth grade group had participated in the e-mail activity several times.

Prior to sending her first e-mail message to the two groups, Lori speculated that their mathematics abilities would be composed of basic computation skills with large numbers. She felt strongly that she would be challenged to write good problems for these students because of her uncertainty about their personal interests or their skills. "If I'm supposed to ask them questions without having any prior knowledge of what they're working with, I'm not sure how good I will be at sending appropriate problems." She knew that it would be somewhat difficult under the circumstances to find challenging and interesting problems at the skill levels of the students. As a result of these perceived challenges, Lori spent time looking through various resources to

develop an idea of what the children should be able to do at those levels. She felt that writing good problems would get easier as she developed an understanding of what her students could accomplish.

Lori said that the elementary students saw her as someone who was their challenger; someone who made them think. She felt that her role would be to provide them with feedback to help build their problem solving skills as well as their self-concept. She structured her problems and her additional communications to address these items.

Both of Lori's groups wrote responses allowing her to understand the processes they used in solving her mathematics problems. The Pennsylvania students were more structured in their problem solving approach than were the Alaska students. The Pennsylvania group was likely to try to write an equation to solve the problem, where the Alaska group was less methodical in their strategy. Lori enjoyed this contrast. She said that there were several instances when she had to spend time trying to understand what the Alaska students did to arrive at their solution. They worked things out in ways that were totally different than approaches she would have used to solve the same problem. Lori said, "Sometimes I have a hard time figuring out what they did to solve it [the problem] just because my mind doesn't work this way." The students from Pennsylvania solved the problems more consistently with the way Lori would have solved them herself. Lori felt that these different approaches made her aware that not everyone reasons the way she does. In fact, the Alaska group was more interesting to her because of their deviation from a more standard approach.

Although Lori enjoyed the uniqueness of the processes used by the Alaska students, their unusual ways of addressing the problems were somewhat troublesome for her early in the activity. When the students sent an incorrect answer, Lori tried to gear her hints and suggestions toward a more traditional way of solving the problem–her way of solving the problem–instead of hinting at less structured approaches. Kilpatrick suggested that this and similar phenomena often occur in school situations; students are not allowed to create their own meanings for problems because teachers too tightly structure their assistance (1985). After Lori recognized what she was doing, she changed her feedback so students would have more flexibility in their approaches.

Problems sent

In her initial interview, Lori felt that appropriate mathematical problems would be those dealing with concepts familiar to the children, but a bit beyond what they currently could do with ease. She said that the problems would not be simply computations, and that they would make the children *think*. When selecting problems to send to her groups, she carefully considered these criteria (see Table 4). The problems Lori sent came from many resources. She used commercial problem solving books, problems from the mathematics teaching methods course (Van De Walle, 1994), and she also made up several of her own problems based on events happening in her life.

Lori not only used a variety of sources to find her problems, she also tried to select several different genres of problems to send. She was not completely sure if the problems she was sending were good ones for the students. Being forced to find problems to send to them made her realize that it was not a simple matter to select a problem that would challenge students without being too overwhelming to them. She said that locating good problems made her skeptical of textbooks; text problems often did not require much reasoning. She put herself in the students' position to try to think about what they would do to solve items she sent to them. This helped her determine if it was a good selection.

Lori sent the same problems to both of her groups each week with the exception of the final problem. During the last week of the activity, the Pennsylvania group sent Lori a problem to solve. Lori chose to forward this problem to her Alaska group. Despite what Lori identified as much different solution strategies between her two groups, she felt that their skill levels were similar enough where she could send them the same problems. This allowed her to really focus on their different strategies and techniques.

Providing good feedback to her student groups was very important to Lori, and she did it well. She wanted to help build the children's problem solving skills as well as their self-esteem through this e-mail activity, so she tried to address their work in a very positive way through her feedback. Even if they did not get the correct answer, Lori's messages to them showed them how much she cared about their work, and how much

Table 4

Lori's Weekly Problem Selections

Week	The Problems Sent	Sources Used
1	I have a recipe for hot chocolate that will make five eight ounce cups of hot chocolate. How many cups would I have if I used ten ounce cups?	TOPS deck.
2	At a sports store there are three advertisements for baseball bats in the front window. One says, "Slugger bats $5.00 each." The second says, "Arrow bats, $6.00 each, buy 4 and get 1 free." The final advertisement says, "Champion bats, 2 for $11.00 and $15.00 off when you buy twelve." If I want to buy 20 bats, which is the best deal?	Math textbook series.
3	I am looking for a two-digit number. If added, the sum equals 8. If the digits are reversed, the number formed is 18 less than my number. What is it?	TOPS Resource book.
4	You are trying to see how much money you need to go on a trip to anywhere you choose to go. Your trip to anywhere you decide will last five days. On these days you may need money for meals, snacks, spending money, money for a place to stay, and also consider how you will get to wherever you are going. I want to know where you choose to go, the total amount of money you will need, and how much money you will need for each item you choose (example;food=$___)	Made up.
5	Farmer Bob has twenty-two animals on his farm. Of all these animals, there is a total of sixty legs. How many pigs and chickens does he have?	Math teaching methods textbook.
6	John, Sara, Amy, and Denise had a contest to see who could sell the most cookies during a school bake sale. John sold more than Denise. Sara sold the fewest. Amy sold more than John. In what order did the contest come out?	Math teaching methods textbook.
7	This weekend my family and I are going to Chicago, IL to the Bears and the Steelers game. My dad told me it would take about five and 1/2 hours to get there from my home town which is two hours away. Estimate for me how many miles I will be traveling if I drive 60 miles per hour and how much money I will spend on gas if my car gets 20 miles per gallon.	Made up.
8	Tony and Wendy play marbles almost daily. Since Tony is a better player, he agrees that, when he wins, Wendy pays him 5 marbles, but if Wendy wins, Tony will pay her 8 marbles. In one month they play 26 games and they each ended with just as many marbles as when they began. How many games did Tony win?	Math teaching methods textbook.
9	Tom, Dick, and Harry work in a bank. One is the manager, one is the cashier, and one is the teller. The teller, who was an only child, earns the least. Harry, who married Tom's sister, earns more than the manager. What job does each one have?	Math teaching methods textbook.
10	Ted's weight on earth is three times as much as his weight on the planet Mercury. Ted's weight on Jupiter is seven times as much weight as his weight on Mercury. If Ted weighs 90 lbs. on earth, how many pounds would he weigh on Jupiter?	Received from PA group and then sent to Alaska group.

their efforts meant to her. She tried to point out the important aspects of the problem without telling them exactly what to do to solve the problem. Her groups responded very well as a result. Unlike several of the other student groups involved in the e-mail activity, Lori's students did go back to solve the problems over again if they did not get a correct answer the first time. It is likely that the feedback provided by Lori was a largely responsible for their efforts.

Problematic and positive interactions

The problematic interaction that Lori selected was her response to one of the Alaska messages. In her response, she asked the students to go back and check their work. She gave them a suggestion for what they might try to do as they tried the problem again. After Lori examined their work again, she realized that they actually found a correct answer to the problem the first time. Not only did Lori initially fail to see that they had solved the problem correctly, she also did not recognize their creative approach to the problem.

Lori chose this interaction as being problematic for two reasons. The obvious reason was that she incorrectly told them that their answer was wrong. Secondly, in her feedback to the group, she told them specifically to write an equation for the problem rather than encouraging them to use their own strategies. To Lori, this was the worst part of her response. "...I was imposing what I would do....That's just me dealing with what I was taught." Lori had enough insight to recognize her "help" as an imposition rather than as assistance, since she was directing their problem solving approach rather than letting them come up with an effective method. Once she recognized what she was doing, she discontinued providing feedback that was as directive.

The positive interaction that Lori selected illustrated her interest in the alternative methods of problem solving used by her Alaska group. Their message was written as follows:

> Hi my name is Nicholas and I like sports all except hockey. I don't know what else I like.
>
> Hi my name is Chad I like sports too. My favorite sport is football. I play for the Cowboys in Little League I'm the quarterback. In the picture [photographs were exchanged] I have dark blue jeans. My favorite foods are pizza, tacos, spaghetti.
>
> Hi my name is Jenny. My favorite foods are corn and pizza. I don't like any sports. My favorite color is dark blue. I'm 11 years old. Chad is 10 years old and same with Nick. There might be a knew kid in our group named Roni.

> THE ANSWER
> We checked all of the bats. First we made a chart and we had the Champion bats were $95. Then the Slugger bats cost $100 and the Arrow bats cost $120. For the Champion bats we put 2=11 and then we did 4=22 and kept adding like this 6=33 and when we got to twelve we got 66-15=51 and then we put 14=62 and so forth. Champion bats cost the less.

What made this positive to Lori was that each of the group members wrote some information about themselves, and then they gave a detailed description of how they arrived at their solution. In addition, they solved the problem in a unique way. In fact, Lori said that they made *her* really think in order to figure out what they did. Although she desired to teach younger kids who would have less developed problem solving skills than students in either of her two e-mail groups, she felt that what she learned about how children think made her aware of things that would help her work more effectively with the lower grade levels.

Authenticity

Lori enjoyed her participation in the e-mail activity. She said that she liked checking her e-mail to see if she had any messages from her elementary groups. Although she was leery of the activity at first and thought that it would be a time-consuming exercise with little return of the investment, she soon changed her mind. On the "realness" scale, Lori rated the activity very positively. Explaining her view of the authenticity of the activity, she said:

> I think that why it's real to me is that *they're* real. They're real kids saying things like "P.S. You spelled John wrong." It makes it fun because they're real people. How can it not be fun to communicate with them? I think about who wrote that [the different parts of their messages]. I take out their pictures and think about who it was. Obviously I'm learning a lot about myself and how I think about thinking.

Rather than considering the children as merely some faceless names with whom she communicated on a weekly basis, Lori clearly viewed the elementary children as real human beings and treated them as such. She identified her personal communication with them as one of her strengths in the activity. This was a positive part of the activity for Lori. Figure 5 shows how she rated both the e-mail activity and her field experience.

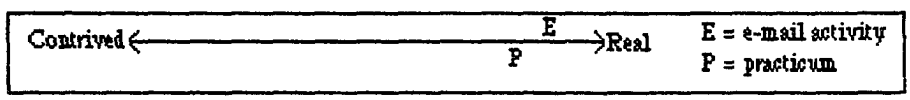

Figure 5. Lori's perceptions of the e-mail activity and the practicum experience as real activities.

Lori's rating of the e-mail activity was very interesting when compared to her rating of the practicum. Although the rating indicated her positive view of the field experience, she actually perceived the e-mail activity as being more real. Part of this may have stemmed from a negative experience with a previous practicum cooperating teacher. In her prior practicum placement, Lori was paired with a teacher whose teaching philosophies were much different than her own. She was intimidated by this teacher and felt that she was treated as another student rather than as a professional. Despite a more positive mathematics and science practicum, the prior negative experience caused her to rate the field experience as less genuine than the e-mail activity.

Lori believed that the e-mail activity challenged her to write good responses to student messages. This was something she felt she could do, however. The confidence in her mathematics skills and in her ability to deal with the elementary students in a positive way contributed to her feelings of adequacy toward the activity.

Lori felt that as a result of her involvement in the e-mail experience, she came to understand her own way of solving problems. She realized how difficult it was for her at times to recognize alternate approaches to the standard methods that she would use, but she became aware that it was important to allow children to expand on their own processes rather than doing something imposed by her. Lori realized that providing student assistance was an area in which she needed continued growth; she identified this as her weakness with respect to teaching mathematics.

Lori's minimal anxiety toward mathematics was demonstrated in her involvement in the e-mail activity. She was paired with children who were older than those she would be certified to teach, but instead of looking at this negatively, she welcomed the opportunity to learn how slightly older children process information. She used her involvement in the e-mail activity to examine her own problem solving processes. Because her two groups used different problem solving approaches, she saw contrasting methods that helped her better understand how she could address problem solving from a teaching perspective.

Lori was a basically shy person, but the distance between her and her e-mail student groups provided an environment that felt very comfortable to her. She believed she could get to know the students quickly because she was less inhibited than she would be in a real classroom situation. Even though she was not with them in person, she still felt an attachment and a connection to her student groups. Certainly face-to-face experiences

with children in real classrooms were important to Lori as well, but the e-mail activity was also a positive learning environment that helped to prepare her for the teaching field.

Overview

Several aspects of the e-mail activity provided learning opportunities that the practicum did not facilitate. The e-mail activity gave Lori the opportunity to work with an older group of children than she had previously worked with. In addition, she felt that in the e-mail activity, she had to really try to understand how the students were thinking so that she could redirect them if they needed it. Lori suggested that this was not a necessity in a face to face situation because you could just tell the students something else to try without understanding the reason for their first approach. Since she did not really get a second chance to provide feedback to the student groups on each of the problems, it became very important to her to thoroughly understand their reasoning and methods. She felt that she became skilled at explaining things without being able to specifically show them what to do.

Lori felt that there was a different relationship between her and her e-mail groups than there was with her practicum students. She felt that she had not really formed a real strong relationship with her Pennsylvania group because they did not share as much about themselves as the students in the Alaska group. A bond had definitely been established between Lori and the Alaska group, however. The students at the Alaska school became comfortable enough to say, "P.S. You spelled John wrong," and they also told her that one of the group members just sat there and did nothing one week. On the other hand, she said,

> How could I not be closer to the practicum students when they're *there*? They can see me and talk to me and tell me these stories. They can see how I am. It's totally different when I teach them to solve something or show them what they could do than when I just send things through e-mail.

Lori believed that it takes time to develop a comfortable relationship with students. Because the practicum was such a short duration, it was difficult for her to establish a close bond with those students, even if she did get to be with them in person. She suggested that she was actually more comfortable with her e-mail groups than she was with the students in her practicum. She said that although the potential was greater for developing a relationship with kids when you can be with them in person, that it may be easier initially to develop a

relationship through e-mail. In an e-mail environment, both parties may be less inhibited, especially if they are reserved like Lori.

This was not meant to imply that she developed a better relationship overall with her e-mail groups than her practicum students. Lori said that she could get to know the kids from her practicum at a different level than she could with her long-distance groups. She claimed, "It goes beyond problems being sent every week with a few additional comments." She could do mathematics in a more real-to-life way in her practicum. The comparison was more evident in the following quote:

> [In the practicum experience] I get to know who they are, where they came from, what they know or don't know when they are working on a problem. I can't see this over e-mail. The distance is kept. They are kids that I work with, but they don't know me and I don't know them. The practicum allows you to deal with children as they are everyday, the problems that they face. You can take situations and create an opportunity for learning.

Although there was a relationship established with the students in her e-mail groups, because she was not able to be with them in person, that relationship was different than what she had formed with the students in her practicum.

Lori felt very strongly that a field experience was important in terms of providing opportunities to observe children actually working out problems. She suggested that it may have been difficult for students to write about their processes through e-mail. She believed that she might have developed a better sense of how the children really solved problems if she could have watched them work. She felt that she could provide more initial assistance in person than she could through e-mail. She also said that she could not determine if the problem solving process was a group effort or if it was just one or two students working on what she sent them.

The distance provided by using electronic communications was both a benefit and a hindrance for Lori. It was beneficial because she could learn about students quickly and more easily than she could with limited face-to-face contacts such as what was provided in her practicum. She could open up to the students and be more personal with them via e-mail than she was likely to be in a classroom. The e-mail activity forced her to really understand their processes since she did not get a second chance to provide feedback. On the other hand, she could not see the students solve the problems directly and she could not provide assistance when it was most needed. These missing elements were important to her.

Michan

Personal background

Michan was another of the mathematics teaching methods students identified as having a low anxiety level toward mathematics. Her MARS score was 123 at the beginning of the semester and 144 when she took it the second time. Michan thought that the scores on the instrument accurately depicted how she perceived mathematics. Michan's dad posed lots of mathematical problems to her as she was growing up, and it made the subject fun for her. Her high school mathematics teacher also helped her feel confident in her mathematical abilities.

This confidence surfaced in her choice of college majors. Michan did not choose an education major when she first enrolled in college. Rather, she began her college coursework in engineering, and took trigonometry and calculus courses as a result. She did well in those classes, although she was initially scared of failing because of their reputation for being difficult. She said that she studied harder because of this commonly held belief among students.

Michan enjoyed her engineering coursework, but she decided that engineering was not the career that she wanted to pursue. She could not see herself being an engineer for the rest of her life. Michan had always considered teaching as a career option, and she gave it more thought after engineering seemed less satisfying to her. For a while she considered teaching high school mathematics, but then decided that she would like to work with younger children instead.

In the e-mail activity, Michan was paired with fourth graders from Virginia and third graders from Oregon. To select appropriate problems for these student groups, Michan believed that knowing their classroom curriculum would provide her with a good starting point. She relied on the teachers involved in the e-mail activity to familiarize her with the mathematics content that the children knew, and she also used scope and sequence charts to help her get a general sense of what concepts were studied in the third and fourth grades. She thought that using information from events of interest to students, such as sports events from the weekend, would be helpful.

The student groups

Michan thought her student groups would be able to perform addition and subtraction using large numbers. She also thought that they should have at least a conceptual understanding of multiplication and division and that they should have some experience working with simple story problems. By the end of the e-mail activity, she also learned that they could work with combinations and rates.

Michan suggested that the students in each group had little experience solving mathematical problems prior to the e-mail activity. She based this opinion on some of their responses indicating that they were unaware of effective processes to use in solving the problems. She said that sometimes they were unable to even select the information needed in order to solve the problem.

The students' lack of problem solving skills was not an impediment for Michan, however. Michan thought of the e-mail activity as an opportunity for her growth as a teacher. She said,

> I like to be able to, when we learn something, to put it into practice to see if it really works. Not that I doubt what the teacher tells us. When I can hear it and see it, I can remember it a lot better. If I learn how it works, and put it into practice, I get a lot more out of it. So I think it will be a good experience.

Michan viewed this activity as a chance for her to apply her ideas about teaching and mathematics to situations involving children. She mentioned her inexperience writing mathematical problems on several occasions and believed that the e-mail activity would help her become more proficient at that skill. She considered being able to see how students solve mathematical problems beneficial to her. In addition, the e-mail activity was another opportunity for Michan to work with children.

Problem selection

Michan's perception of what constituted a good problem was based primarily on being able to identify appropriate content and language based on the ability level and interest of the students. She believed that for third and fourth grade students, items should not be too "wordy". She felt that the content of problems should be familiar to the students. These were characteristics that she tried to address in her problem selection. Overall, she was successful in doing so. Table 5 lists the problems sent by Michan to her student groups.

Table 5

Michan's Weekly Problem Selections

Week	The Problems Sent	Sources Used
1	For both groups: I have 11 coins in my pocket that equal $0.92. Can you tell me what those coins are? You will probably find more than one way to make 11 coins equal $0.92. Tell me all of the ways that you find.	Observed in a previous practicum.
2	For both groups: A pilot flew in a straight line from Seattle to Miami. How many miles did she fly and how many states did she fly over?	TOPS problem solving deck.
3	For both groups: How many days or years would it take to give away a hundred dollars if you gave it away at the rate of one dollar a minute? A thousand dollars? A million dollars?	TOPS problem solving deck.
4	For both groups: If it takes 500 kids 10 minutes to bake 2000 cookies, how long would it take them to bake 1000 cookies? 200 cookies?	From *Teaching Children Mathematics* .
5	For both groups: If A=$0.01, B=$0.02, C=$0.03, ...X=$0.24, Y=$0.25, and Z=$0.26, guess the name of my favorite cartoon (animated) character if it's worth $0.66 and has 6 letters. (Hint: It's orange). Can you think of a word worth $1.25? Make a list.	Math methods course discussion.
6	For Oregon: No problem sent to the Oregon group this week due to schedule conflicts.	TOPS Problem Solving deck.
	For Virginia: If you roll 2 dice and find the sum of the number you rolled, how many different sums can you get? Make a list. What if you rolled 3 dice? How many different sums can you get? Make a list. Here's an example: If I used 2 dice and I rolled a 3 and a 2, my sum would be five. And so on. Using 3 dice I might roll a 4, 6, and a 1, my sum would be 11. And so on.	Math methods course discussion.
7	For both groups: Laura and Mandy were trading baseball cards. Laura said that 3 Steve Garvey's equal 1 Reggie Jackson and that 1 Reggie Jackson equals 5 Pete Rose's. How many Garvey's would Laura trade for 15 Rose's?	TOPS Problem Solving deck.
8	For Oregon: No problem sent to the Oregon group this week due to schedule conflicts.	
	For Virginia: Use these nine digits (1,2,3,4,5,6,7,8,9) to make 1000. Use all of them. You may arrange or combine them in any order. You may use any operations such as +,-,x, or divide. Write down the equation you create. There are several possible solutions. Try more than one if you have time.	Math activities book.

Table 5 (continued)

Week	The Problems Sent	Sources Used
9	For both groups: How many different sundaes can be made from this list of ice cream and toppings? Make a list of as many sundaes as you can think of. Ice cream: vanilla (v), chocolate (c), peach (p), strawberry (s), chocolate chip (cc). Toppings: hot fudge (hf), strawberry (s), butterscotch (b), marshmallow (m), pineapple (p). Here's an example of a sundae: 1 scoop of v and one scoop of c with topping hf. Or 1 scoop s with toppings s and m. You can use no more than 3 scoops of ice cream and no more than 3 toppings. You don't have to always use that many, you might only want 1 scoop of ice cream and 1 topping. It's up to you. Be sure to make a list of all your sundaes.	Math activities book.
10	For Oregon: Study this pattern. Can you see how addition is used to get the next row? Hint: 3+3=6. What numbers would be in rows 6 and 7? 1 1 1 1 2 1 1 3 3 1 1 4 6 4 1 For Virginia: No problem sent to the Virginia kids this week to give them a chance to catch up.	TOPS Problem Solving deck.

Michan used a variety of sources to find the problems she sent to her student groups. The first week, she sent a problem that was similar to an activity that the teacher in her previous practicum posed on a routine basis. Each day the teacher would grab coins out of a drawer and ask the students to find all of the different coin combinations that would give them the amount that was in her hand. Michan adapted this idea to meet the needs of the children in her groups within the constraints of the e-mail activity. Since the Virginia children were studying measurement, she selected and altered a measurement problem found in the TOPS Problem Solving decks for one of her other selections. In another message, Michan adapted a problem from an article found in *Teaching Children Mathematics* so that it was appropriate for her groups. She adapted problems discussed in the mathematics teaching methods course and some from a mathematics activity book as well. Michan felt that she had done a good job selecting appropriate problems for her students groups, based on the feedback they provided to her.

The Virginia kids did well with the problem solving activities that Michan sent to them; they usually tried more than one way to solve each problem and were able to make good progress toward a solution. The Oregon group, on the other hand, was more difficult for Michan to assess. Their answers seemed to be more off-track. For example, in the problem asking them how long it would take 500 kids to bake 1000 cookies, the Oregon students said it would take 1 hour and 40 minutes to bake 1000 cookies and 20 minutes to bake 200 cookies. The initial problem stated that it took only 20 minutes to bake 2000 cookies, so theoretically it should have taken less time or the same time to bake fewer cookies, rather than more time. Because their answers were so far from correct, she was not sure if the problems were simply too difficult or if she was just not explaining her problems clearly enough for the students to understand what she was asking. She adjusted her problem selection and her explanations to account for the difficulties that the Oregon group was having. She started providing hints and examples to try to clarify what she wanted the students to do.

Problematic and positive interactions

When asked to indicate a problematic interaction that occurred during the activity, Michan chose an Oregon response to a problem asking them to find eleven coins that equaled ninety-two cents. The group found six ways to make the correct amount of money, but only one of the ways used eleven coins. The other five of their combinations used more or less coins than that. This troubled Michan. She said that she must have either stated the problem wrong or that the students misinterpreted what she said. After she sent them feedback to clarify the situation, the group went back to solve the problem again, but they only came up with three combinations meeting the criteria that she defined. Michan hoped that the students would find more combinations than only three. She realized that part of their difficulty may have stemmed from a misunderstanding of what she expected them to do, especially if their teacher did not routinely ask them to form exhaustive lists of combinations of items.

Like the Oregon group, the Virginia group also failed to address all of the possible solutions to the coin problem. The difference between their response and that of the Oregon group, however, was that they suggested three out of the six possible combinations that met all of Michan's requirements. At least they had demonstrated some understanding of what Michan expected them to do in the problem.

Michan felt that her response to the Virginia group's solution to the coin problem showed one of her weaknesses in this activity. She felt that she had a difficult time providing feedback when the answers to the problems were not correct. She said, with respect to her response to this message,

> In this one, I was glad that they sent three different answers. I wanted them to see if they could find more, but I thought that they had halfway figured it out. So I told them, "Good Job." I wish I would have shared the ways that I found. I should have been more specific in this case regarding the feedback that I gave to them. I wish I would have asked them how many more ways they could find.

Rather than encouraging them to be more thorough in their response, Michan allowed them to think that they had discovered all of the possible solutions. Had they known that there were other combinations meeting the criteria, they may have found more solutions. By telling them that they had done a good job, Michan gave them the message that it was fine to stop after they had found only a few solutions. This response troubled her.

Despite the negative elements in this interaction, there were also some positive aspects of it. Because she was not sure where the misunderstanding occurred, Michan took more care in her later messages to make her explanations clear to the students. She even provided examples of the type of response she was looking for when it was appropriate to do so. She felt that although these misunderstandings could emerge in regular classroom situations, the teacher would be able to quickly rectify the situation. In the e-mail activity, however, this was not the case. Since the preservice teachers were not present to deal with student questions as they emerged, they had to make more adaptations to make their problems clear enough for the students.

The interaction that Michan selected as positive was a response from the Virginia group to a problem asking them to determine how many miles were flown between Seattle and Miami. Michan chose the response that the students provided to this problem as positive because they clearly explained their method for solving the problem. They used a ruler and a map in their process, which was another positive aspect. Michan also liked that some of the students mentioned their personal experiences with flying in their answer, indicating that they saw a connection between the mathematics they were doing in the e-mail activity and mathematics in the real world.

Authenticity

Michan rated the e-mail activity very highly in terms of her perception of the activity as authentic, as indicated in Figure 6. Since the elementary students viewed the activity as exciting and important–and she believed that creating that type atmosphere was a part of her role in the activity–it felt genuine to her. Michan believed that since she would be creating problems once she became a teacher, finding items to send to her students in this activity helped to prepare her for her future career.

Not only did the activity help her to locate good problems, it also helped her to see how the items she chose may cause difficulties for students. Michan said, "I have to be really careful in wording problems because I can't show what I mean [through e-mail]." She would have preferred actually being there to help the students herself, but she said that it was good to try to find ways to explain things in words without showing someone directly. In fact, she said that sometimes in face-to-face situations, teachers provide too much direction to their students so that the students really do not have to solve the problem on their own. Kilpatrick found this practice to be commonplace as well (1985).

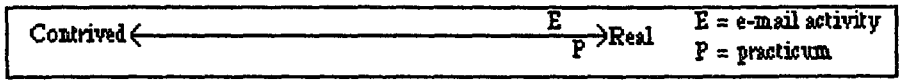

Figure 6. Michan's perceptions of the e-mail activity and the practicum experience as real activities.

Michan recognized the importance of being able to actually see how the students solved problems, and the e-mail activity was limiting to her in this respect. She said that there were times when a teacher could understand more through observation than what the students could document on their own. She felt that students may sometimes not realize they used a strategy in solving a problem–so they could not write about it as a result.

The practicum allowed her to observe and to question the students to help them develop mathematical problem solving skills in a way that could not be accomplished using electronic mail. Michan's ratings reflected these views. After being in the classroom for several weeks, she observed different mathematical activities that addressed the NCTM Standards, including the use of many manipulatives. Her cooperating teacher

allowed Michan to have sole responsibility for the class while Michan taught. The practicum was a very positive experience for Michan as a result of these factors and she rated it very highly in terms of being a genuine learning experience.

Like Lori, Michan did not specifically feel challenged by the e-mail activity. "I like math a lot, so I feel like I can try anything" was how she responded when asked if she felt that she went beyond what she thought she could do. Although Michan listed several areas of personal growth in this activity, it was considered to be more of a learning experience rather than a challenge to her. Because Michan had confidence in her mathematical skills, she was able to focus on the students during her involvement in the e-mail activity. She did not have to exclusively focus on her performance, but rather could look at how she could best facilitate the growth of her students' problem solving skills.

Overview

Although there were some negative aspects of the e-mail activity for Michan, she indicated that it helped her learn more about using electronic mail and also how to find good problems to use with children, although this was not an easy task for her. "It is tough to find problems or think up problems, and then try to adjust them [based on the capabilities of the students]. Each time, I'm trying to give them a harder problem [to help in their problem solving development]." She was trying not only to find problems that interested them, but also ones that challenged them as well.

Michan used a somewhat scientific approach when she determined the kinds of problems appropriate for her student groups–it was a methodical and structured exploration. When she sent problems that were not appropriate for her student groups, she learned from the experience and made adaptations in the next items that she sent to them. She learned that she needed to use careful wording because it was easy for the elementary students to misinterpret something, and she did not have the option of being there in person to clarify it for them. She thought carefully about what it meant to help the students develop mathematical problem solving skills, and she tried to address this skill development through her problems and feedback.

Michan did not seem to have the difficulty in working with the Virginia students that both Jessica and Chelsea described. Part of the reason may have been that Michan's group had a student member who was a good

leader according to the classroom teacher. Another part of the reason may have been that she sent them problems that were appropriate based on their mathematical and problem solving skills. Michan said that when the students responded to her questions, they told her if the problem was too easy or too hard, so she was able to develop a sense of their skill levels and adjust her problems accordingly. She would have preferred that the elementary students elaborated more than they did, but what they wrote to her was still helpful. She felt that the comments made by the Virginia teacher helped her assess her problem selection as well.

Like Jessica, Michan addressed the limitation of the once per week communications with the elementary student groups in terms of facilitating student problem solving growth. She felt that the structure of the e-mail activity did not encourage students to try solving a problem again, even if she asked them to do so. She thought it would be better to continue having the students work with the same problem until they got it right or at least used a good problem solving approach. Michan thought that bi-weekly communication with her groups would have been more effective than once a week messages so that she could help them sooner if they did not understand the problem.

Michan did not feel any anxiety with respect to the e-mail activity. However, she said that some of the feedback from her students was not adequate to help her understand whether the problem was at an appropriate level for them. She said that sometimes the students said that they solved the problem in their head rather than more clearly defining to her what they did. She believed that at times they did not solve the problem mentally even if that was what they said they did, and rather used this explanation as an excuse for not communicating their process more thoroughly.

Michan had a field experience that was very valuable and worthwhile to her. She was very involved with the children when she was in the classroom–the teacher let Michan be completely in control while she was there. This only happened because Michan's cooperating teacher sensed that Michan was ready for such an experience. Michan appreciated the opportunity and felt that she learned a lot as a result of being in charge. In the e-mail activity, she had a similar degree of control. For Michan, this was important. She did not need to have as much structure as some of the other preservice teachers because she had the confidence and skills to experiment more independently. No experience would have been as real for Michan as a face-to-face experience

in a classroom. However, the e-mail activity still allowed her to work with children to help them increase mathematical problem solving skills, just as she would do in an actual classroom.

Erin

Personal background

Erin was another class member identified as having a low anxiety level toward mathematics. Her initial MARS score was 123, and this decreased to 112 upon the second administration of the instrument. The results of the anxiety scale were no surprise to Erin. She always enjoyed mathematics and was never nervous about the subject. Her dad was an engineer, and although he did not push Erin or her two sisters into mathematics or science, he never gave them the impression that it was something they should not do. Erin took four years of high school math and did well in those courses. Erin identified her interest in and excitement toward mathematics as being strengths with respect to teaching this subject to children.

Erin always wanted to work with children, but when she first entered college, she enrolled in a pre-physical therapy program instead of in an education program. She wanted to specialize in physical therapy with children. After she volunteered at a physical therapy clinic and saw how painful the treatments were for some of the patients there, she decided to alter her career choice. Before initially deciding on a college major, Erin contemplated becoming a teacher. After considering her options, she decided not to teach because of the lack of status associated with the profession. She re-evaluated teaching after her brief experience with physical therapy and decided it was the career that she wanted to pursue.

Despite the confidence and success that Erin had in mathematics, rating the problems on the Problem Set was difficult for her. She said that she really did not know what kinds of items would be appropriate for the students she would work with in the e-mail activity. She did not know the mathematical concepts that students learned in the different grade levels. Erin said that when she evaluated the items on the Problem Set for their appropriateness, "I felt like I was guessing all of the time."

The student groups

Erin worked with third graders from Oregon and fourth graders from Virginia during the e-mail activity. She tried to address the needs of these students in her messages to them, but was initially unsure what types of problems would work well for them. She was excited about the opportunity to work with the students, however, and thought that the activity would give her additional experiences with children.

As the activity progressed, Erin felt that she gained a better idea of what to look for when searching for problems to send to her groups. "At the beginning [of the e-mail activity], I looked through the cards [the TOPS Problem Solving decks] and didn't really know what I was looking for. I don't know how I approach it differently, but now when I see it [a good problem], I know if it's what I want to send." She developed an understanding of the types of items she considered to be good ones to use in this activity.

Another of the factors that may have influenced Erin's problem selection was her understanding of the kinds of mathematical skills that her groups had. After the e-mail activity had been in progress for several weeks, Erin felt that she had developed a good idea of what the children could do. When the e-mail activity first began, she thought about the difficulty level of problems in terms of her own mathematical ability rather than the skills of the elementary students. She said, "I had a hard time when I was choosing the problems because for me, all of the problems seemed so simple." After several weeks, she was better able to think more about what the students could solve with the skills they were likely to have. Erin was able to think about the difficulty level from their perspective. During the e-mail activity, she discovered that these third and fourth grade students had more mathematical skills than she expected.

Erin made an effort to send problems that were "different" from things that the students were likely to encounter in their classroom mathematics curriculum. She said, "Since I only send them one problem a week, I'm sure they do all kinds of [other] problems in class. I look for ones that are really different, so they're not the same as what they do during their regular math classes." She was looking to expand their problem solving capabilities.

Erin felt that it was somewhat difficult to develop a good understanding of the ability levels of the students in her Oregon group. The group correctly solved most of the problems that she sent to them, and they

made satisfactory progress on the problems that they did not solve correctly. Because she did not observe how they reacted to more difficult problems, she had not learned their upper limits. Erin speculated that if she had sent them some harder problems, she may have been able to better determine their limitations.

Erin believed that she developed a good understanding of the skills of her Virginia group. She felt that the problem solving skills of these children were not as advanced as those of her Oregon group, despite being one year older. The students often did not make good progress toward a reasonable solution to a problem. "They [the Virginia students] just attempt some things and whatever they get is what they write back to me...[In one problem, the students only completed one step toward the solution] and then they didn't do the rest. But they didn't realize that they had forgotten to finish it." The classroom teacher's comments about the progress of the students helped Erin to fill in the gaps that the students themselves left in their messages. Erin preferred that the students would have written more about their problem solving process to help her understand their involvement in the solution, but she accepted the lack of feedback as an indication of the skills of the group. She was not nearly as frustrated as were Jessica or Chelsea regarding the lack of communications provided by her Virginia group.

Problems sent

Erin indicated that a good problem was one involving real things and not just digits or numbers. She thought that the problem should not be too wordy since the children might become confused with the use of complex language. Although she thought that the students should be able to perform basic operations and do some simple two- and three-dimensional geometry by third and fourth grade, Erin felt that she would have to initially use commercial problem solving resources to establish some idea of what would be appropriate for her student groups. She thought that it would be a challenge for her to figure out what to send to them.

This challenge manifested itself in her initial problem selection. Erin was excited about the opportunity to work with the elementary students during the semester in the e-mail activity. However, she discovered that it was not going to be a simple endeavor as she had initially believed. After finding a problem to send to her groups the first week, she said, "I didn't realize how hard it is to write problems. I will definitely

need to work on this." Erin acknowledged that it would take some trial and error before she developed skill in writing or locating good and appropriate problems for her student groups.

The problems that Erin sent to her groups were from either the TOPS Problem Solving decks or they were ones that she composed herself (see Table 6). Some of the problems that she wrote were related to activities that the students were doing in their classrooms. She was aware that the Virginia kids were taking a field trip to Jamestown, so she made up a problem that asked them to figure out how many miles it was for them to make the trip . The following week, she asked them to figure out how much the gasoline would cost for the trip. Erin felt that these two problems interested the students more than some of the others that she sent because of their relevance to the rest of their curriculum. She had a sense of the types of topics that would engage students.

She sent several logic problems to her student groups where reasoning skills needed to be used to find the solution. It was interesting that she chose to include this type of item because of her belief early in the semester that this was not an appropriate type of problem for her student groups. The idea of what Erin believed was appropriate was altered during the course of the e-mail activity as she gained a better understanding of the skills and interests of the students she worked with.

Overall, Erin felt that she was successful in writing problems addressing the mathematical skill levels of her student groups. She said that the direct feedback from the students was a key to her success. Erin felt that children are often not willing to share their feelings about the difficulty level and appropriateness of problems the way that they did in this activity. She said,

> In a real classroom situation, you're not always going to have the opportunity to [have the students] come up and tell you about what they're doing. It's a little less threatening for them to come out and say it [in this activity] since they're writing to me through e-mail. It's not like they have to go up to the teachers' desk and say it.

Erin thought that having the students provide this feedback to her helped her assess their level of understanding and willingness to accept a challenging problem.

Table 6

Erin's Weekly Problem Selections

Week	The Problems Sent	Sources Used
1	For Oregon: How many ways can you put 5 marbles into 2 cans? Make a list.	TOPS Problem Solving deck.
	For Virginia: Ask your teacher for a map of Virginia. Locate your city on the map and mark it. Then locate Jamestown on the map and mark it too. Draw a line between the two. Using the map and its scale, how far is Jamestown from your home?	Made up based on what she was doing in the social studies methods course.
2	For Oregon: Julie delivers 40 newspapers each day, Monday through Saturday. On Sunday, Julie delivers 60 newspapers. How many newspapers does Julie deliver each week?	TOPS Problem Solving deck.
	For Virginia: Your class decides to drive to Jamestown to see the city. The bus you are riding on uses one gallon of gas for every 8 miles of driving. If gas costs $1.09 per gallon, how much will the gasoline cost for the trip? Make sure you figure the total amount for both ways, to Jamestown and back home again. (Hint: use the distance from your first problem to help you.)	Made up based on what she was doing in the social studies methods course.
3	For both groups: Mandy forgot the names of her friend's kitten, dog, and parakeet. She knows the pets' names are Queen, Duke, and Angel. Help Mandy decide which names goes with each pet. Queen is smaller than the dog; the kitten is younger than Queen; the kitten is older than Angel.	TOPS Problem Solving deck.
4	For Oregon: What is the magic number? It is less than ten. When you count by 2's, you say the magic number. When you count by 3's, you say the magic number.	TOPS Problem Solving deck.
	For Virginia: Some birds were sitting on a wire. Four birds flew away. Now there are half as many birds on the wire. How many birds were on the wire at the start?	TOPS Problem Solving deck.
5	For Oregon: Some birds were sitting on a wire. Four birds flew away. Now there are half as many birds on the wire. How many birds were on the wire at the start?	TOPS Problem Solving deck.
	For Virginia: What is the magic number? It is less than ten. When you count by 2's, you say the magic number. When you count by 3's, you say the magic number.	TOPS Problem Solving deck.
6	For Oregon: No problem sent to the Oregon group this week due to schedule conflicts.	
	For Virginia: I had 2 quarters and 2 dimes. I spent some of the money. I have 3 nickels left. How much money did I spend?	Based on money unit in the social studies methods course.

Table 6 (continued)

Week	The Problems Sent	Sources Used
7	For Oregon: Suppose you had eight dimes and seven pennies. You bought a $.49 hot dog. You gave the clerk five coins and got one coin back. How many coins would you have left?	Based on money unit in the social studies methods course.
	For Virginia: You have 5 bags of marbles: The first bag has 1 marble inside. The second bag has 3 marbles inside. The third bag has 5 marbles inside. The fourth bag has 6 marbles inside. The fifth bag has 8 marbles inside. You want 14 marbles and you must take whole bags. Which bags will you take? Can you find 3 different answers?	TOPS Problem Solving deck.
8	For Oregon: No problem sent to the Oregon group this week due to schedule conflicts.	
	For Virginia: There are 27 students in the second grade classroom, but two kids are sick today and one more is in the nurse's office. The second grade teacher has special treats for her students, but she doesn't quite have enough for everyone. She needs your help to figure out how to divide the treats, so that all of the students get the exact same amount. If she has 18 candy bars, how much does each student get to eat?	Made up.
9	For Oregon: If you have one pumpkin pie and there are 7 people who want a piece, how many cuts do you have to make to divide the pie evenly?	Made up.
	For Virginia: You have a six inch by twelve inch piece of paper laying on top of your two foot by three foot desk. How much of the total area of the desktop is covered by the paper?	Made up.
10	For Oregon: You have 25 people in your classroom and one of your classmates brings in cupcakes for all of you. Your classmate brings in 30 cupcakes though and they need to be divided evenly between all of the students in the class. How would you divide them (step by step) and how many cupcakes would each student in the class receive?	Made up.
	For Virginia: No problem sent to the Virginia kids this week to give them a chance to catch up.	

Problematic and positive interactions

The positive and problematic interactions identified by Erin happened to be within the same student message. The part of the message that Erin selected was as follows (punctuation written as in the actual text). It was written by the Virginia teacher.

> I am thrilled that the practice using the amp scale over a week ago has stuck with this group! I am also pleased that they are talking about fractional parts, even if I can't quite decide why they ended up with 65! I would guess that it wasn't exactly 3/4 of an inch, and they were estimating...WOW!
>
> The bad news is that this group came to me and wanted to use calculators...until I asked them to explain why...then they abandoned that idea...I don't know if they gave up because they realized they didn't need them, or if they didn't want to try to explain it to me...

What Erin found positive about this message was that she provided the students with the opportunity to practice a skill they had recently acquired. She felt like she had successfully identified an appropriate problem for them to solve based on this response–although she admitted getting lucky because she did not know, when she wrote the problem, that they were working with map skills in their social studies curriculum.

What she found negative about this same message, however, was that the teacher frowned upon the use of calculators. Erin felt that the use of calculators to solve the problem would have been appropriate since the focus of the problem was not the calculation. She commented, "I had not intended it to be an exercise in practicing their basic skills, but rather an exercise in problem solving." Although the students found a way to solve the problem without using the calculator, they were discouraged by the teacher to use the mathematical tool that was available, and Erin felt this was wrong.

Authenticity

Erin said that the e-mail activity was an authentic experience for her. She rated it approximately seven-eighths of the way on the realness continuum (see Figure 7). She believed this activity felt genuine to her because there was more involved in the activity than simply the mathematical problems. She said that it was real to her because when she selected the problems, she thought about how the students would approach the problem when solving it. She tried to think about whether the problems would be appropriate for her groups. She speculated about how the students would begin solving the problem. She said:

> It is kind of like, on Friday, "Oh, I have to do that e-mail thing." But when I sit down to do it, I really enjoy it. I always wait until Friday to see if I can get more responses from the students [often the responses were sent late in the week]...When I don't get them, I'm disappointed. It's real for me. I don't know about for the students, although I would think that it's exciting for them.

The activity felt real enough to her that when it ended, Erin said that she missed it. Even though there was no face-to-face contact with the students, there were aspects of the activity that were valuable to her.

Figure 7. Chelsea's perceptions of the e-mail activity and the practicum experience as real activities.

The practicum had elements that made it more real to Erin than the e-mail activity in some ways, less real in others. Erin was physically with the students during her field experience, so it was definitely real in that she got to see and work directly with children while she was there. But she felt that she was more of an observer or an assistant for the first part of her practicum, and this was somewhat negative. Erin completed tasks such as putting stickers on student work or drawing lines on papers for parent signatures for the first hour of her weekly three hour time block in the classroom. During this part of each visit, she did not get to interact with the children at all. In the e-mail activity, on the other hand, Erin sensed that she had at least some control over what happened, and that she had the opportunity to interact with the groups. It was interesting that she felt she had more control over what happened in the e-mail activity since the activity's structure was fairly rigid. However, Erin could choose her own problem and decide on the feedback and other communication. A factor in her perception of control may have been that her expectations in the field experience were different than those in the e-mail activity.

Overall, however, the practicum experience was a learning opportunity for Erin. She gave it the same rating on the "realness continuum" as she gave the e-mail activity. Despite not working with the students for the first hour of her weekly visit, she was very involved with the children in the last two hours. She felt that her cooperating teacher was very enthusiastic about the mathematics curriculum that had been adopted during the school year. Erin learned from both the students and her cooperating teacher. Because the practicum had such a positive impact, her high rating of the e-mail activity was very significant.

Although Erin felt generally comfortable with her role in the e-mail activity, choosing to send logic problems that included no numbers felt somewhat risky to her. She did not let this feeling prevent her from sending the problems, but she was initially unsure of their appropriateness. When Erin rated the Problem Set at

the beginning of the semester, she gave the logic problem that was on the instrument the lowest possible rating. When questioned about why she sent this type of problem despite her earlier rating, Erin said, "Things have changed a lot. I never really thought of those as math problems before. I don't know what I thought they were. I viewed them as little problems that you would get out of a book....All math was numbers when I was in school." The e-mail activity helped make Erin more aware that mathematics involved other concepts beyond merely computations. To make this adjustment, she put her beliefs on the line.

Although Erin took a chance by sending logic problems, she commented that there was less risk involved in doing so in the e-mail activity than in a real classroom situation. She was not there when the students worked with the problems that she sent to them, so she did not have to deal with student difficulties. "It's more of a risk if you have to teach it to them as a lesson where you're actually teaching it. Then you have to deal with it if it doesn't work. Whereas this way, I just send it, and if it doesn't work, I can kind of dump it on the teacher." Although it was not Erin's intent to "dump things on the teacher", she viewed the e-mail activity as an exploratory one for her to learn about the mathematical problem solving skills of children. She said that this was an opportunity to try out things on a real group of students without worrying about having to react on the spot as she would do if something went wrong in a face-to-face situation. Erin felt that the e-mail activity was a "practice" environment for the preservice teachers, whereas the field experience did not feel like practice to her.

Overview

The e-mail activity could not replace a practicum experience for Erin. She felt that there was little opportunity for one-on-one interaction with students in the e-mail activity. Erin felt that there needed to be students actually present for her to understand completely how they solved a problem and why they chose the methods that they did. In the e-mail activity, she did not know how students reacted when they first read their message from her. She also commented that there were times when the students did not elaborate enough on their comments to provide an understanding of what they meant by their remarks. In the practicum, she could actually ask students questions to help clarify the meaning of their comments. She never got to meet the kids that she communicated with in the e-mail activity, and this was a negative aspect of the project for her.

She believed, however, that the e-mail activity allowed her to develop materials for groups of children, unlike her practicum where she had to develop lessons for the whole class. She said that in the e-mail activity, the focus could be specifically on problem solving rather than on the development other skills. It also gave her the chance to learn about the capabilities of students of that age level. Erin said that in a regular classroom situation with one teacher and over twenty children, it would be very difficult to provide enough problems that would be at the right level for everyone, so this activity helped her seek a variety of problems that she could use with children of different ability levels.

Erin suggested that the e-mail activity allowed her to practice being a teacher (by choosing problems) in a non-threatening setting. She said that since she did not have to directly deal with student questions about the problems that she sent, she did not have to worry about her selections as much as she would have if she had to answer the students' questions of the students. She still tried to meet the needs of the students, but she felt she could do so in the e-mail environment. The e-mail activity allowed her the time to think about the appropriateness of problems. Because she did not have to deal with discipline in the e-mail activity, she felt that she could focus all of her attention on the mathematical problems and therefore help to develop her skill in writing them.

Erin discussed several positive aspects of using e-mail to communicate with elementary children. She thought that the children might be more likely to truly express themselves through that medium because it was less threatening to do so through e-mail than in person. However, she also felt that the children may not be able to express their problem solving process in writing as well as they would be able to do verbally. She felt that the e-mail activity helped her really focus on mathematical problem solving rather than having to deal with the multitude of other factors that emerge in a real classroom. She did not have to deal with discipline problems, something she identified as being a weakness of hers. Because she did not have to deal with behavior, she felt that she took more risks through the e-mail activity than she would have in her field experience. She did not have to deal with the consequences if the students had difficulties.

Summary

The chapter depicted the challenges encountered by the six women as they tried to carry out their assignment. It reflected beliefs that the preservice teachers had about mathematical problem solving, the skills that they thought children would have at given grade levels, and also about their own abilities to write and/or locate problems for the students that they worked with. Reviewing their reactions to the e-mail activity may help researchers better understand the value and worth of using telecommunications as a learning tool in the teacher preparation curriculum.

Each of the six case study participants reacted differently to the e-mail activity based on what they believed was their role, their comfort level with mathematics and problem solving, and their perception of the activity as authentic. Providing an in-depth description of the involvement of each of these people allowed for a depth of understanding their trials and conquests as individuals during the project. The next section will pull together this information to make generalizations about involvement in the activity.

CHAPTER V. RESULTS

This chapter presents the results of the study. A broad perspective of involvement in the e-mail activity was sought by collecting several pieces of data from all class members. The interviews with the six case study participants allowed for an in-depth look at the total involvement of these women in the activity throughout the semester. The in-depth interviews and the collection of all of the data together helped to provide a complete picture of the preservice teachers' reactions to the e-mail activity.

This chapter is an examination of the areas of emphasis of the study. It is organized into the following sections–each depicting one of the broad research questions: 1) the involvement of the preservice teachers with their student groups, 2) the authenticity of the activity for the preservice teachers, 3) the influence of mathematical anxiety levels on the preservice teachers' involvement in the e-mail activity, and 4) the possibility of using electronic communications in teacher preparation programs. A summary of the results is also provided.

Preservice Teachers' Involvement in the E-mail Activity

Although it was not possible to provide a complete picture of the involvement of each of the preservice teachers who took part in the e-mail activity, the combination of the class results along with the more in-depth look at the case study participants provided a meaningful examination of the activity. In fact, several trends emerged with respect to the preservice teachers' involvement with their elementary student groups:

- The problems selected by the preservice teachers did not always match the characteristics of good problems defined by the preservice teachers;
- The sources used to select problems were influenced by the preservice teachers' understanding of the students' skill levels;
- The overall quality of items sent improved during the e-mail activity;
- Providing feedback to the elementary students was difficult for the preservice teachers, especially when an incorrect solution was found;
- Communicating with real children was an important element of the e-mail activity;

- The preservice teachers realized the importance of helping children to explain their thinking.

The following sections expand upon each of these trends.

Problem selections

An analysis of the quality and types of problems sent by the preservice teachers provided a look at what criteria the preservice teachers used to select problems to send to their student groups and how those criteria changed during the activity.

Early in the semester, the preservice teachers defined what they believed were qualities of good problems. Several of the preservice teachers identified items that were real life situations as being good problems to use with their students. Also named as a characteristic of a good problem by the preservice teachers was that the item should not have an immediately apparent answer; the preservice teachers believed that students must think and reason to figure out what to do. In addition, having more than one correct answer was also a desirable quality. These stated characteristics of good problems were consistent with what the NCTM suggested as being a quality problem. Because these qualities were identified by the preservice teachers, it was speculated that the items they selected to send to the elementary students would conform to their criteria.

One of these criteria was that an item should force students to think and reason. This meant that the item should be one where the students had to develop a strategy in order to find a solution. Computations put to words did not address this criteria, yet items that were simple calculations surfaced each week of the e-mail activity. An example of an item considered to be a simple computation was Chelsea's problem, "John has just finished reading a new story book. He read 30 pages a day for 9 days. How many pages did the story book have?" Students needed to only recognize this as a multiplication problem and then perform the computation. Another example was, "Julie delivers 40 newspapers each day, Monday through Saturday. On Sunday, Julie delivers 60 newspapers. How many newspapers does Julie deliver each week?" Here the students had to perform a series of additions. Neither problem involved thinking or reasoning for the upper-level elementary students who received each of the items.

Another of the inspected items was the number of real life problems sent. A "real life" type of problem was considered to be one with an actual purpose. One example was Lori's problem dealing with her

trip to Chicago to see the Bear's game. In the problem, she asked students to find how many miles she traveled and the amount of money she spent on gas. The students could relate to the situation and view it as a realistic one since it could be something they might encounter in their lives.

The results of this analysis were somewhat surprising given the emphasis on problem solving in the course. Although a higher percentage of computations were sent during the first two weeks of the e-mail activity than later on, there were always at least two computations sent during each week of the activity. This was disappointing when compared to the number of "real-life" problems that were selected and sent. During only two of the ten weeks did the number of real-life situations surpass the number of computations sent. In one other week, there was an equal number of both types of items sent (see Figure 8).

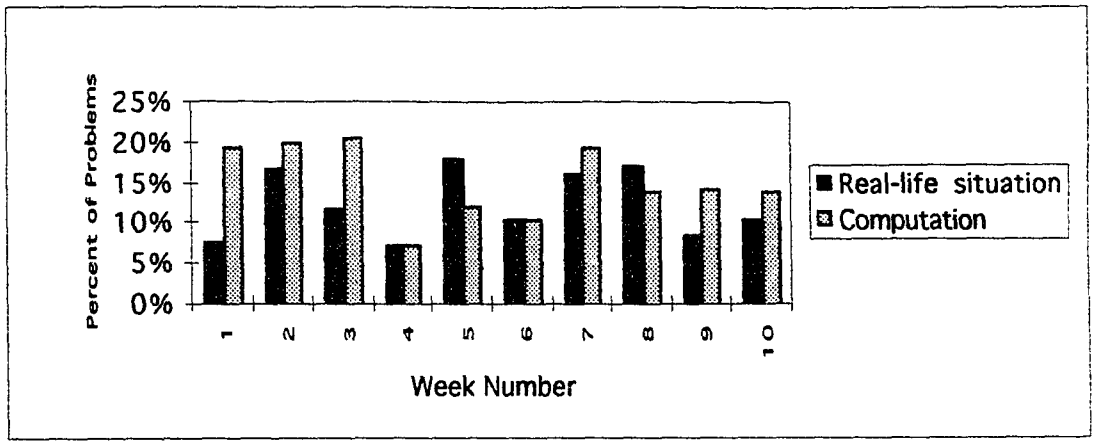

Figure 8. The number of "real" problems sent each week compared to the number of items that were computations. The percent of problems is out of the total number of items sent during each week.

There was a slight overall increase in the number of real types of problems sent after the first week of communications, but the highest number of real-life types of problems sent in any given week was six. Considering the total number of problems sent each week, this was not a very high proportion. Since the preservice teachers were aware of characteristics that I, as the instructor, and the NCTM considered good problems, they either did not recognize the computations as being inappropriate, or they chose to send the items despite their understanding of the problems' poor quality. One possible reason for the lack of real-life problems

was that this type of item was not as familiar to the preservice teachers as a computation put to words, so they sent what they were accustomed to solving themselves. Additionally, real types of problems were generally not found in the commercial resources that the preservice teachers chose to utilize. Real types of problems generally had to be created from scratch. Because the preservice teachers were not very comfortable with their problem selections overall, they more often chose to send items that felt safer to them, and the computations were much more secure.

Another of the qualities mentioned by the preservice teachers as being a desirable characteristic of a problem was the possibility that more than one solution was possible. An example of one such problem came from Michan. She wrote, "Use these nine digits (1,2,3,4,5,6,7,8,9) to make 1000. Use all of them. You may arrange or combine them in any order. You may use any operations such as +,-,x, or divide. Write down the equation you create. There are several possible solutions. Try more than one if you have time." Despite Michan's attempt at providing problems with multiple solutions, the majority of the items sent by the preservice teachers required only one specific answer (see Figure 9). There was some progress, however, in weeks five through eight, when a higher proportion of problems had multiple answers.

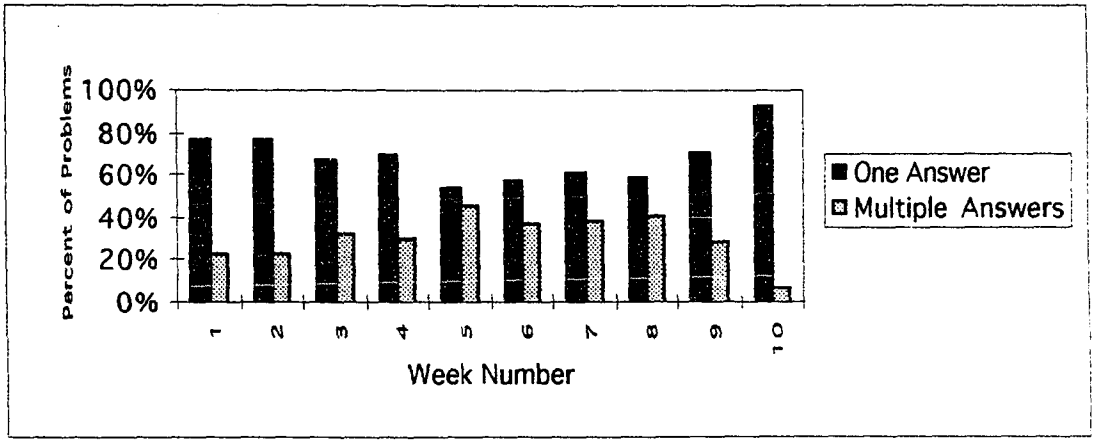

Figure 9. A comparison of the number of items sent with only one possible answer to those with multiple possible solutions during each week of the e-mail activity.

It appeared that the preservice teachers simply wanted the activity to end by the tenth week, since most of the problems sent then had only one solution. That was a busy time of the semester for both the preservice teachers and the elementary students due to classes ending and the upcoming holiday season. Problems with multiple solutions took more time to find and also often more time for the elementary students to solve. The preservice teachers wanted to be sure to leave enough time for the elementary students to respond to the problem so that they still had time to send feedback before the termination of the activity.

These data indicated that the preservice teachers did not always follow their own guidelines for good problems, especially at the beginning of the e-mail activity before they had a solid understanding of the skill levels of their student groups. The qualities that they described as being desirable were often not present in items they solved when they were students. The preservice teachers were not as comfortable and familiar with the types of items they described as they were with those they selected. Selecting problems consistent with what they described may have been outside of their zone of proximal development (Vygotsky, 1978). In addition, it may have been difficult for the preservice teachers to choose one specific word problem consistent with the NCTM's idea of problem solving as an entire process. Often, word problems found in commercial resources or even those composed from scratch do not completely address the idea of problem solving.

Sources used to select problems

The case study participants used elementary mathematics textbooks and scope and sequence charts early in the activity to help them learn the mathematical skills normally covered at the grade levels of their student groups. They used these resources to understand the mathematical concepts studied at earlier grade levels as well. It was not a course requirement to look at these resources; the preservice teachers chose to use them to learn more about the mathematical abilities of the children in their groups. Searching through the textbooks became meaningful to the preservice teachers in this context since browsing through textbooks helped to inform them about what they could expect their student groups to do. The preservice teachers also discovered how few problem solving opportunities there were for elementary children in many of the textbooks.

The actual sources used to select problems were varied among the different preservice teachers. Several of the preservice teachers used elementary textbooks to find problems, despite the lack of quality items in many

of the texts. Sometimes these problems were adapted to be more appropriate for the student groups and to better address the idea of problem solving. Other times, the items selected from the textbooks were computation problems with no true problem solving focus. The mathematics teaching methods textbook had a problem solving chapter containing a large number of items (Van De Walle, 1994). Several of the preservice teachers took advantage of this resource and sent problems from this source. The TOPS Problem Solving Decks (1980) were another commonly used resource. Each of the decks corresponded to a different grade level, so the preservice teachers could look through many cards before settling on something they considered appropriate for their particular student groups. Some of the preservice teachers became comfortable enough to experiment with creating their own mathematical problems from scratch or to base a problem on something they learned in a teaching methods course, observed in a school, or read in *Teaching Children Mathematics*, the NCTM journal for elementary teachers. Figure 10 depicts the sources used to locate problems by the case study participants.

There was much variation among the preservice teachers with respect to their comfort levels in creating new problems from scratch. This was reflected among the case study participants. Emily, Erin, and Chelsea took advantage of the opportunity to try out problems that they made up on their own. Chelsea had many doubts about whether the items she sent were appropriate for her students, so she used packaged resources early on to help her to feel more confident that what she was sending was at least in approximately the right age-range. Jessica did not make up any of the problems on her own and instead relied heavily on commercial problem solving resources. Jessica experienced some of the same frustrations as Chelsea with trying to develop an understanding of what her students could solve, so the packaged problems were helpful to her. Unlike Chelsea, however, she never ventured into writing her own problems.

The reliance on commercial resources for finding problems to send decreased after the first three weeks of the e-mail activity. Early on, the preservice teachers were simply trying to discover the abilities of their student groups. Commercial resources helped them to gauge what might be appropriate. After they established some sense of their students' ability levels, the preservice teachers were more likely to write their own problems to send. Among the case study participants, there were 21 items sent that they created on their own versus 22 items selected from the TOPS Decks. Although several other selected items came from textbooks, this was a

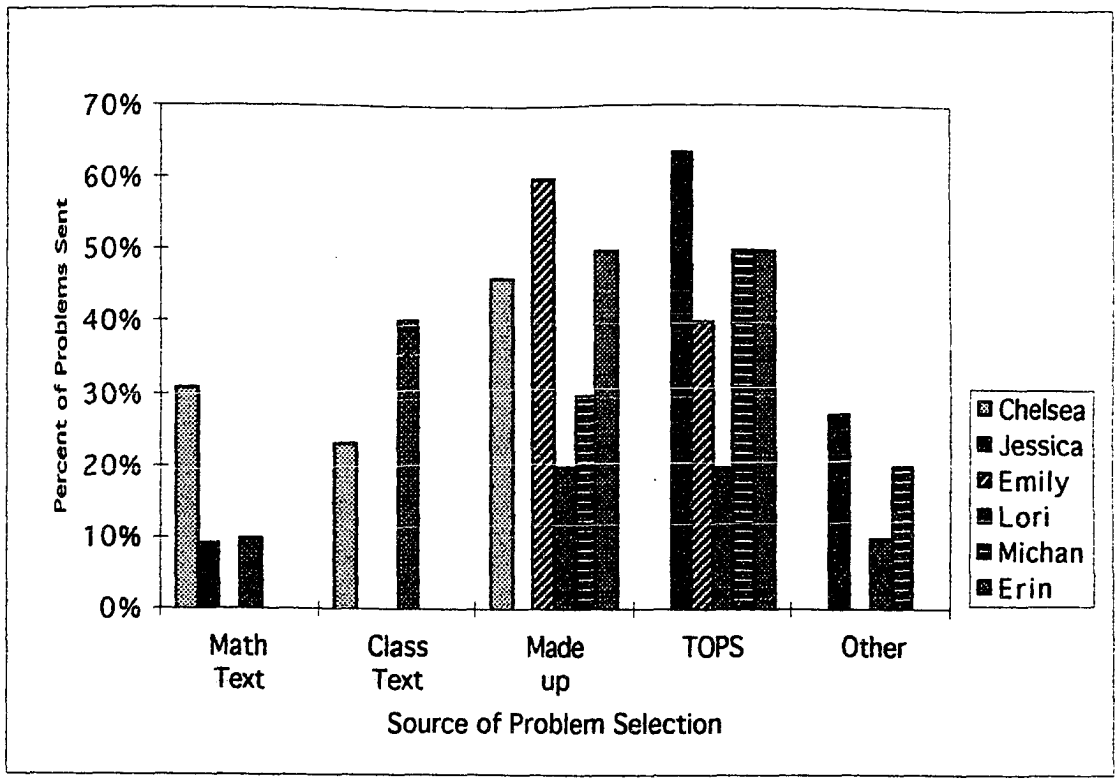

Figure 10. Sources that the case study participants used to locate the items that they chose to send to their elementary student groups. The chart represents the percentage of each of the case study participants' total problems coming from each of the sources.

promising discovery overall. It indicated that nearly one-fourth of the items sent by the preservice teachers to their student groups were items that they created on their own. If the first three weeks of the e-mail activity were removed from this analysis, the results would be even more enlightening.

Examining the sources used by the preservice teachers to select problems provided information about the preservice teachers' participation in the activity. One item that was clear was their lack of confidence with respect to writing their own problems. Many of the preservice teachers did not feel comfortable, especially at the beginning of the e-mail activity, creating items from scratch. They may not have been ready to take this step; as in selecting items that matched their stated criteria for good problems, it may have been outside of their

zone of proximal development (Vygotsky, 1978). It is very possible that ten weeks was not long enough for the preservice teachers to not only assess the skill levels of their student groups well enough to try a problem on their own. It is also possible that ten weeks was not enough preparation time for them to consider such a venture. It is possible that reliance on commercial products also depicted a lack of overall creativity; however, materials created for the class showed that many of the preservice teachers had creative ideas for teaching mathematics.

Problem ratings

An examination of the ratings of the problems sent by the preservice teachers depicted the overall quality of the items sent throughout the e-mail activity. Each of the problems was rated during the third and ninth week of the activity. The problems were rated on a five-point scale, with a 5 indicating that the item exhibited qualities of a good problem and that it was at a good level for the student group. A 1 indicated that the item exhibited none of these qualities and/or that the item was too hard, too easy, or unclear for the student groups. All ratings were shared with the preservice teachers.

During the third week of communications, only 22% of my ratings of problems were fives. Fifty-six percent of the ratings were fours or fives. In the ninth week, 51% of the problems were rated as fives, and 71% of the items were rated as a four or five. The mean ratings of week three (3.7) and week nine (4.2) were significantly different, $t(65) = -2.1$, $p < .05$. This suggests that as the preservice teachers became more comfortable with the e-mail activity and their elementary student groups, their problems were more consistent with the characteristics specified by the NCTM. These results are summarized in Table 7.

The participating teachers who chose to score the problems rated the problems consistently between the two weeks, with a mean rating of 4.0 in week three and 4.1 in week nine. Their ratings are summarized in Table 8. There was no significant difference between the teacher ratings in those two weeks, $t(21) = .067$, $p > .05$, however only two of the participating teachers rated the ninth week problems and the total number of problems rated was small in both weeks (13 items rated during week 3 and 10 items rated during week 9). The differences between the instructor ratings and those of the participating teachers may have been caused by different perceptions of what constituted appropriate problems. I focused on whether the items were consistent

Table 7

Instructor Week 3 and Week 9 Ratings of Items Sent by the Preservice Teachers

	Week 3			Week 9		
Rating	# of problems with that rating	Percent of problems	Cumulative percent	# of problems with that rating	Percent of problems	Cumulative percent
5	7	22%	22%	18	51%	51%
4	11	34%	56%	7	20%	71%
3	13	41%	97%	9	26%	97%
2	0	0%	97%	1	3%	100%
1	1	3%	100%	0	0%	100%

with characteristics documented by the NCTM Standards. The classroom teachers may have based their ratings more on whether or not their students had the necessary skills to solve the problem.

There was evidence that the quality of problems went through at least some degree of transformation during the e-mail activity. The quality of the problems based on the NCTM's criteria was higher near the end of the activity than it was earlier, suggesting that the preservice teachers became more comfortable sending good problems to their student groups. This indicated that an e-mail activity may help preservice teachers identify and select problems exhibiting the characteristics specified by the NCTM. However, there was still room for improvement of the problems sent by the preservice teachers. Future e-mail activities could be structured to better address the quality of problems. For example, class time could be spent discussing the selections made by the preservice teachers and also how the elementary students responded to the problems. These discussions may help facilitate the preservice teachers' development of an understanding of what might be appropriate for their student groups.

Table 8

Participating Teachers' Week 3 and Week 9 Ratings of Items Sent by the Preservice Teachers

	Week 3			Week 9		
Rating	# of problems with that rating	Percent of problems	Cumulative percent	# of problems with that rating	Percent of problems	Cumulative percent
5	8	62%	62%	5	50%	50%
4	1	8%	70%	3	30%	80%
3	2	15%	85%	1	10%	90%
2	0	0%	85%	0	0%	90%
1	2	15%	100%	1	10%	100%

Problem Set evaluation

The Problem Set (Appendix B) was administered to the preservice teachers prior to the e-mail activity and then again at the end of the e-mail activity. Only two of the ten items showed a significant rating change over this time period (see Table 9). One of these items was item two, which was, "The tens digit is two less than the ones digit. The difference between the ones digit and the hundreds digit is the same as the tens digit. The sum of all of the digits is equal to three times the ones digit. What is the number?". On the first administration of the Problem Set, the mean rating given by the preservice teachers on this problem was 2.4. On the second rating, the mean was 3.7, $t(24) = -4.5$, $p < .001$. The preservice teachers were much more comfortable sending this type of item after they saw that their student groups could solve problems of this type.

The other item with a significant change was item three, a basic computation. This item said, "Bill and Sue went shopping for a birthday present for their mother. They first bought earrings for $7.95. Then they bought her some perfume for $3.52. They also bought her a picture frame for $5.37. How much was their total?" The mean rating on the first Problem Set was 3.4, while the mean at the second administration was 2.1, $t(24) = 3.72$, $p < .001$. The fact that the preservice teachers viewed this item as less appropriate the second time

they rated it showed that they began to see the difference between a true problem and a simple computation. In fact, their rating of this particular item received the lowest score out of the ten possible items on the second administration of the Problem Set. The three items that allowed for multiple solutions had higher ratings than that of item three. However, the items that they chose to actually send to their student groups did not entirely reflect this trend.

The biggest overall ranking differences on the items on the Problem Set between the preservice teachers and the practicing teachers occurred on items five and ten. The preservice teachers ranked item five as their second highest item out of the ten on the instrument, while the practicing teachers' mean for the item ranked it eighth among the items. Item five said, "You are going on a trip with your parents and they have asked you to help them figure out how much money they will need to set aside for fuel. They are allowing you to choose a city in any state other than your own for the vacation. How much money will they need?" The comments provided by the practicing teachers indicated their uneasiness with the different variables that the students would have to research in the problem. Some of these teachers indicated that it would take too long for the elementary students to compile all of the necessary items required to solve the problem, and that this much time was unavailable for the e-mail activity. The preservice teachers did not have to deal with time constraints, so their higher ranking of the item was not surprising.

It was harder to speculate the difference in rankings of item ten since the item was one that could be solved by creating a diagram of the situation or by listing the possible combinations of games. The item said, "There are 8 teams in a basketball league. Each team plays each of the other teams twice. How many total games are played?" Some of the preservice teachers indicated that the solution could be derived through a simple multiplication (8 x 7). Although this was true, most elementary students would not intuitively know this. Also, since the elementary children worked in groups, they should have been able to prove to their group members that this theory worked by listing the combinations. Justifying their solution would also have also been consistent with the NCTM Standards. The preservice teachers thought that there were better types of problems to use with their student groups, whereas the practicing teachers felt much more positive about the item.

Table 9

Ratings of the Problem Set by the Preservice Teachers and the Participating Teachers

The Item	Preservice Teachers			Teachers
	Mean, Pre	Mean, Post	*t*	Mean
1. You have the task of painting your classroom walls. Each can of paint can cover an area that is 200 square feet. How many cans will you need?	3.1	3.3	-0.62	3.1
2. The tens digit is two less than the ones digit. The difference between the ones digit and the hundreds digit is the same as the tens digit. The sum of all of the digits is equal to three times the ones digit. What is the number?	2.4	3.7	-4.47*	3.3
3. Bill and Sue went shopping for a birthday present for their mother. They first bought earrings for $7.95. Then they bought her some perfume for $3.52. They also bought her a picture frame for $5.37. How much was their total?	3.4	2.1	3.72*	2.3
4. What are the next 4 digits in the following pattern? 3 7 1 1 1 5 1 9 2 3	3.3	3.0	0.37	1.9
5. You are going on a trip with your parents and they have asked you to help them figure out how much money they will need to set aside for fuel. They are allowing you to choose a city in any state other than your own for the vacation. How much money will they need?	3.6	3.7	1.66	2.4
6. On a test, I had 7 times as many correct answers as incorrect answers. There were 120 items on the test. How many items did I get correct?	3.2	2.8	1.66	3.0
7. Fred, Walter, and Duc live next to each other. They are a teacher, a medical doctor, and a salesperson. Walter lives in the middle house. When Duc went on a vacation, the medical doctor kept his dog. The teacher and Fred share a fence. What work does each person do?	3.4	3.8	-1.49	4.0
8. How many times does your heart beat in a year?	3.7	3.5	1.04	3.0
9. Bob worked twice as long as Dan. Dan worked one hour more than Jim. Jim worked 2 hours less than Pedro. Pedro worked 3 hours. How many hours did Bob work?	3.5	3.6	-0.28	4.1
10. There are 8 teams in a basketball league. Each team plays each of the other teams twice. How many total games are played?	3.3	3.3	0.01	4.0

* $p < .05$

Another critical issue examined with respect to the Problem Set was whether the preservice teachers rated the problems more consistently with the ratings of their participating teachers after working with the children for ten weeks. The mean ratings of each of the Problem Set items for the entire mathematics teaching methods class were compared to the mean ratings of the participating teachers (see Table 10). When the preservice teachers initially rated the Problem Set, there was a significant difference between their ratings and the practicing teachers' ratings on seven out of the ten items. The number of items with a significant difference upon the second rating of the Problem Set was only four. The preservice teachers' ratings of the items on the Problem Set were more consistent with the practicing teachers' ratings as they learned about the skills of the students they worked with. This was a positive implication of the activity. Although they did not work with the students in a classroom setting, the e-mail activity enabled the preservice teachers to develop some sense of what would not only be practical but also appropriate for a specific group of elementary children.

Since there was a lot of variation among the practicing teachers' ratings due to the diverse age and ability level differences, it would have been interesting to compare the ratings of the preservice teachers with the participating teachers of their student groups. However, the number of preservice teachers working with each given practicing teacher was too small to look at statistical differences between the ratings at each of the sites in a meaningful way.

Feedback

Because the preservice teachers worked on a one-on-one basis with each of their groups, the opportunity was present for them to elaborate on the elementary students' responses to help these students build their problem solving skills. Some of the preservice teachers took advantage of the opportunity to do so. Other preservice teachers responded with feedback that was unlikely to help in problem solving skill development.

When the elementary students solved problems correctly, the preservice teachers had the responsibility to let them know of their success. This was not always done in uniform ways. Several of the preservice teachers simply told the elementary students that their answer was correct, with no further explanation provided. Emily's responses fit this category. When her students solved a problem correctly, Emily told them, "You did a

Table 10

Comparison of the Preservice Teachers' Problem Set Ratings with Ratings of the Participating Teachers

Item Number	t-value of first comparison	t-value of second comparison
1	0.029	1.2
2	-3.2*	1.3
3	3.9*	-0.89
4	5.6*	4.9*
5	4.2*	5.4*
6	0.86	-0.78
7	-1.9	-0.69
8	2.9*	1.9
9	-2.9*	-2.9*
10	2.8*	-3.3*

*$p < .01$

nice job on the last problem." She offered no other affirmation of their response. She did not refer to their message to tell them why their response was correct. In this respect, her feedback to her student groups was rather impersonal and did little to help the students improve their problem solving skills. Emily's responses were not unique. Other preservice teachers responded in similar ways to their student messages. If the preservice teachers did not thoroughly understand what the elementary students did to solve their problem, this response type allowed them to let the students know that they found a correct solution without trying to analyze the strategy.

There were times when some of the preservice teachers provided little or no feedback to their student groups; they simply sent a new problem without any reference to prior messages. The elementary students then did not even know whether their solution was correct. These elementary student groups often responded with

messages that included a plea to the preservice teacher to let them know whether their answer was correct. Although most of the preservice teachers were conscientious enough about their role in the activity to provide feedback to their groups each week, the absence of feedback on occasion indicated that some of the preservice teachers did not see themselves in a teaching role in this activity. It appeared that these preservice teachers' involvement in the e-mail activity was only to satisfy the course requirement, and not to grow as a teacher or to help the elementary students develop skills.

Many of the preservice teachers, unlike Emily, elaborated on why a solution was correct and what was positive about the process that the children used. Lori's responses were of this type. Lori believed that her ability to provide good feedback to her student groups was extremely important in terms of helping them to develop their problem solving skills. She went back to look specifically at the student messages to determine the process that they used, and her feedback referred to their methods. Most of the preservice teachers' feedback fell into this category. This was a positive aspect of the e-mail activity since it showed that the preservice teachers were interested in helping the students become better problem solvers.

The feedback provided for incorrect student responses varied much more widely than responses to correct answers. The most common feedback to incorrect answers was for the preservice teachers to provide an explicit set of instructions for how the problem could be solved correctly, with no reference made to the process that the elementary students used. Chelsea used this method almost exclusively in her feedback. She wrote about which operations she used with the numbers involved in the problem, but did not explain to the children the reasons for her process. She did not provide feedback to the students regarding any part of their solution process that was correct. Rather, she was straightforward in her explanation of how to go about solving the problem correctly. She ignored their incorrect work and instead focused on what she felt was the "right" process. This may have been affected by her comfort level with mathematics. To provide feedback on something specific done by the group, Chelsea and other preservice teachers would first need to understand how the elementary students solved the problem. This may have been problematic, especially since some of the student groups did not always do a thorough job in explaining the steps they took to find an answer.

Another group of preservice teachers looked more carefully at the process used by the elementary students and factored their methods into the feedback that was provided to them. The preservice teachers analyzed where student mistakes were made and pointed these errors out to the students. Because the preservice teachers directly referred to what the students had done, it was an opportunity for the elementary children to discover why their process was incorrect. Some of the preservice teachers asked the elementary students to solve the problem again.

Several of the preservice teachers felt uncomfortable asking the elementary students to solve the problem again if the solution to the problem was not correct the first time. The structure of the e-mail activity somewhat limited them from asking the students to rework their solution. It took several weeks of involvement for both Jessica and Michan to feel comfortable enough to ask their students to try a problem over again with some helpful suggestions for how to proceed. Jessica and Michan both struggled with their students' wrong solutions because they wanted to be positive in their responses, yet having the children go back to try the problem again meant that they had to inform the students that they made an error. On the other hand, the preservice teachers understood that the development of problem solving skills included learning how to analyze mistakes and determine other approaches that might elicit a correct response.

As the activity progressed and the preservice teachers started to get comfortable with their student groups, they provided more hints and direction to the elementary student groups than they did initially. Early on, they were more content to simply provide a correct solution for the students. As the preservice teachers got more confident in themselves, their feedback became more helpful to the students in terms of developing problem solving skills. This was a positive element of the e-mail activity in terms of helping to prepare future teachers.

Problematic interaction selections

There were several different categories of problematic interactions selected by the preservice teachers that helped to determine what the preservice teachers learned and expected from the e-mail activity. One of the categories of problematic interactions dealt with sending problems to the elementary groups that were either too hard or too easy for their students, or were not appropriate for other reasons (see Figure 11).

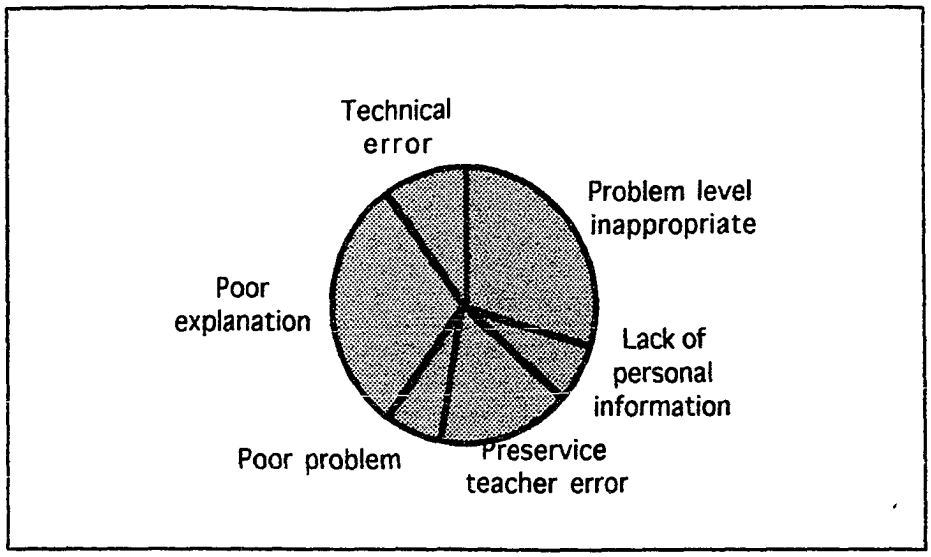

Figure 11. The types of items selected by the preservice teachers as being problematic interactions.

Many of the preservice teachers struggled to find problems addressing the skill levels of the children they worked with. Many of their problematic interaction choices dealt with their frustrations as a result of not comprehending or addressing this level. Some of the examples of the reasons for making certain selections follow.

> "I chose this problem because first of all, the problem is hard to understand. As the response implies, too many numbers were involved for the age level. Plus, they did not have enough knowledge about the sports."
>
> "I chose this problem because it is just a basic computation problem. I now realize the types of problems I am suppose to be sending, but I am still finding it very hard to think of the problems or even finding some. They all now seem like basic computations."
>
> "The problem I gave was too easy. By their response, I don't think that the children were challenged at all by the problem. It is really hard to figure out what kind of problems to send to this group because they [the students] are at a lower [skill] level."
>
> "The most negative feedback came when the group rated my problem a 1 on a scale of 1 to 10, and 1 being easiest. I feel that the problem didn't make them think enough, so it was a waste of time for them and me."

Problems that were both too easy and too difficult were viewed as troubling by the preservice teachers. They wanted to select a problem between the two extremes, but it was often difficult for them to find this zone. The

preservice teachers were conscious of trying to send a problem to their student groups that made them think, yet was within their capabilities. At times, one of these criteria was compromised to address the other.

Poorly written messages from the elementary students was another large category of interactions viewed as problematic by the preservice teachers. This went beyond merely the personal information that was provided– the preservice teachers wrote about instances when the elementary students did not elaborate on their process used to solve problems.

> "I chose this message because the students didn't leave me with any feedback on how they solved the problems, except for that they kept guessing. Well, what strategies did they use for guessing?"
>
> "I felt that this response was problematic because even though they found an alternative correct answer to the answer I had, they didn't do a very good job of telling me how they solved it."

The preservice teachers relied on thorough explanations from the elementary students to help them provide good feedback, for both correct and incorrect solutions. The elementary students' written explanations also helped the preservice teachers understand whether the problem was at an appropriate level based on their skills. When explanations were sparse or missing completely, all the preservice teachers could do was to try to interpret the actual solution that was provided. Even when the answer was correct, the solution itself did not help them to learn very much about how the elementary students solved the problem unless a good explanation of the process accompanied the answer.

Some of the preservice teachers realized that the problems they sent to their student groups, or at least parts of some of their messages, were missing pieces of information that were critical for either solving the problem or helping the children understand exactly what they should find. In the selections of problematic interactions, these elements were mentioned.

> "I didn't explain my problem and response information well enough or they didn't understand how to tell me. I obviously didn't give clear enough directions."
>
> "The trouble with this problem is that I did not tell them how many items I bought or how much money I sent. Without this information the problem is not a very good problem as it is hard to solve without knowing those items."

Other preservice teacher errors were also mentioned. One preservice teacher wrote about telling her students that they were wrong, when she later discovered that they had actually solved the problem correctly. In their quest to

make this a rewarding activity for the elementary children, the preservice teachers felt badly about making errors such as these. These errors were reflected in their problematic interaction selections.

Feedback provided to student groups was also sometimes considered problematic. One of the preservice teachers felt that rather than letting the students come up with their own process for solving the problem, she told the students what they should try. Another college student chose her feedback as problematic for a different reason. Here are clips from both her actual message and also her written explanation regarding why she felt this was problematic.

> (This was from the response to the student group)
> Dear Ross and Eric,
> As for the "easy" problem that I sent you about Pablo's 4 three-cent stamps and 3 four-cent stamps. You only gave me seven different amounts and there should be 18...You asked me if I've ever written an advice-column and actually I AM "Dear Abby" who writes for national newspapers! I hire an older lady to put her picture by my column so I can go in public without people bothering me with their problems.
>
> (This is from her written response regarding the problematic interaction)
> Since we have been writing back and forth, I had inferred from these two boys that they are kind of smart alecks! So, I think I was feeling a little rambunctious the day I responded to their answer about the stamp problem and I stepped beyond the "teacher boundaries" and tried to "stick it to 'em" a little. I see this as a little unprofessional. Rather than remark about their feeling it was an "easy" problem when really they got it wrong, I should have simply explained it without making the jab at the fact that they got it wrong. I also didn't need to respond so sarcastically about the "Dear Abby" joke they wrote to me.

Sometimes the distance between the preservice teachers and the elementary students was beneficial in that it allowed the groups at both ends to be more reflective. On the other hand, because of the distance, sometimes things were written that would not have been said in person.

One of the other types of problematic responses dealt with technical difficulties encountered as a result of involvement in the e-mail activity. One of the preservice teachers had not used electronic communications prior to the mathematics teaching methods course. She had a great deal of difficulty sending her early messages to her student groups. Her selected problematic interaction was a message from the mail server telling her that her message did not get sent. A similar situation was cited by another preservice teacher when her student group did not receive the e-mail message she sent to them containing feedback for the problem they most recently solved. Another example of a technical difficulty was when one of the preservice teachers' groups responded to a problem that was not the one she sent to them. In this situation, the preservice teacher did not know what the

actual problem was, so she did not know how to respond to the students. During the e-mail activity, there were well over 1,000 messages sent to and received from the preservice teachers. Considering this, the actual number of technical difficulties resulting in unsent messages or message mix-ups was very minimal. When it happened, however, it was very frustrating for both the preservice teachers and the elementary students.

Lack of personal information in student messages was listed as a problem by several of the preservice teachers. One preservice teacher wrote, "I have a hard time getting this group to do some personal communication with me. Many times they don't answer the personal questions I ask them and if they do answer them, they are very brief about it. I feel like I am having a hard time getting to know this group." If a relationship could not be established between the preservice teachers and the elementary students, it seemed that the preservice teachers did not view the e-mail activity as positively as some of their peers. They yearned for the e-mail activity to be more than just sending problems to a group of elementary students somewhere around the country. The preservice teachers wanted to know more about these children.

Positive interaction selections

The largest category of positive interactions selected by the preservice teachers was their communications with the elementary students (see Figure 12). The future teachers enjoyed learning about the children in their groups beyond the mathematics part of the activity. The messages that the students sent gave the preservice teachers a sense of who the students were as individuals. For several of the preservice teachers, it was their first experience learning about children at certain ages. Some of the comments made by the preservice teachers regarding this type of interaction follow.

> "I was able to learn more about them personally through what they told me about themselves...At first they would just tell me how they solved the problem and that was it. But now they are opening up more."
>
> "I feel that right from the start, hearing about their interests and what's going on in their lives helped me gain insight into their personality traits which normally is very difficult without meeting them one-on-one."
>
> "Each child wrote a brief note about their interests and hobbies. I felt this was very personal, and therefore very rewarding to me! I felt like these kids really wanted me to know about them, and that they were truly interested in the activity!"

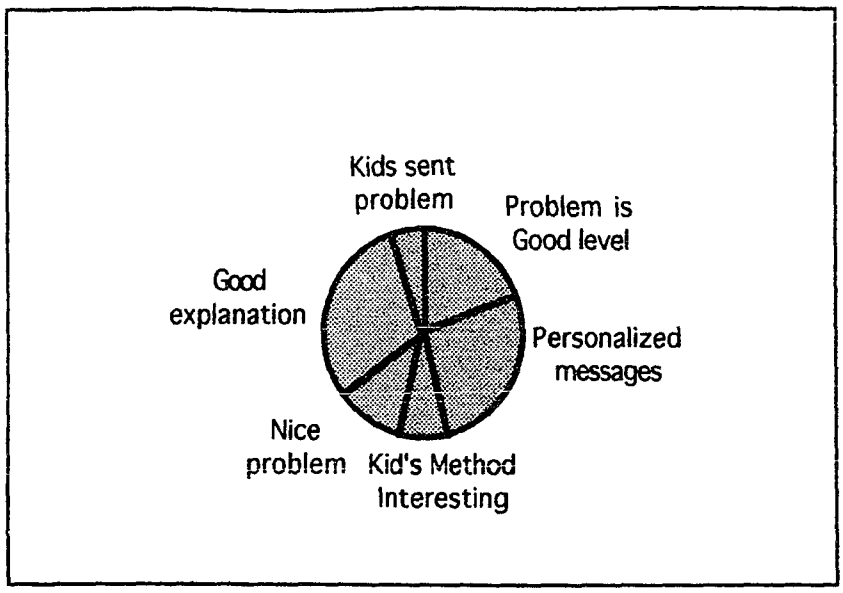

Figure 12. The types of items selected by the preservice teachers as being positive interactions.

It was clear from the number of responses dealing with personal communication from the children, that this was an important aspect of the activity for the preservice teachers. Although they were not involved with the elementary children in face-to-face interactions, the personalization of the messages meant a great deal to them.

There were more preservice teachers listing the inclusion of personal information as being a positive aspect of the e-mail activity than there were preservice teachers listing the exclusion of personal communication being a negative aspect of the activity. This indicated that when students included information about themselves in their messages, it enhanced the activity for the preservice teachers–and that it was not perceived as a requirement of the activity.

Another of the large categories of positive interaction selections was elementary student responses where they clearly explained their process of solving the problem. When the elementary students were able to describe the steps that they took in solving the problem, the preservice teachers gained an understanding of the childrens' reasoning process. Some of the elementary students also wrote about methods they attempted that did not immediately work, and this helped the preservice teachers understand the problem solving process. From

these explanations, the preservice teachers developed a sense of appropriate problems to send to their groups. The following excerpts demonstrate the preservice teachers' reactions to thorough explanations.

> "The section that I marked off is a very good explanation telling me how they solved the problem. I was very pleased, and was able to understand easily how they came up with the answer."
>
> "I feel that this is a very positive interaction because the group began by telling me the strategy they chose to use and why they picked it. They then explained how the strategy was applied to the problem and finally why they chose the strategy over the others they knew about. I found this very good, because it shows me that they have a grasp of the concepts and how to apply them to situations. I found this very exciting because we have been talking about in class the idea of teaching for understanding, not just as rote drill and practice."
>
> "Even though they didn't get the answer the first time, they gave me a lot of feedback and I could see what they were thinking. I knew what they were having trouble with and so I could give them a hint to help them a little and they were able to solve it the next time."

Because the preservice teachers did not get to work with the elementary children in a face-to-face environment, the written explanations provided by the students became very important to the preservice teachers. There was some variability regarding how well explanations were written, and the preservice teachers who did not get good feedback experienced many more frustrations than those who received more thorough explanations. This was very evident with Chelsea and Jessica, who struggled throughout the activity to try to understand their students' processes.

Because this was the first opportunity that many of the preservice teachers had to interact with children in a mathematical problem solving environment, it was very challenging for many of them to send problems that not only made the children think, but also were at a level that matched their mathematical skills. This was reflected when the preservice teachers were asked to choose an interaction that they felt was positive. Many of them chose a message written by the elementary students that specifically told them the problem was either "just right" or "at a good level". Most of the preservice teachers were unsure whether their problem selection was appropriate for their student groups until the elementary children let them know. Some of the comments made by the preservice teachers with respect to this issue demonstrated their lack of self-confidence.

> "I think this is a positive interaction because my students did not find the problem too hard or too easy. They said the problem made them think and that is exactly what I wanted to happen. It made me feel good."
>
> "I think this is positive because the children did the problem on their own and seemed to enjoy it from the response I got that the problem was just about right."

> "This was very positive feedback for me because up until this point, I was having difficulties finding a problem that was at the right level for either one of my groups. In this response, they finally said that the problem was just right or a little hard. I was ok with the "a little hard" part because while I want the students to be successful, I also want the problems to be somewhat challenging for them."

Problem selection was cited by the six case study participants as being something that made them feel insecure. Many of the other class members expressed similar sentiments and were glad when they finally discovered items that were appropriate for their student groups.

Another of the broad categories of items selected as positive interactions dealt specifically with problem selection. Some of the preservice teachers with confidence in their mathematical abilities needed little feedback from the students regarding the appropriateness of their problems. They selected interactions where they believed they chose a good problem for the students to solve based primarily on the NCTM Standards, items that the elementary children were learning in school, or their perception of the skills of the children. They did not need student affirmation of their selection--rather, they were able to self-evaluate. This was not widely found among all of the preservice teachers. Most of them needed the direct feedback from the elementary children in order to make this analysis.

The elementary students from four of the participating sites sent problems to the preservice teachers on occasion. Two of the preservice teachers chose these exchanges as their positive interactions. One of the two said, "I was really impressed that the students sent us problems. I sent them my answer, and I am eagerly awaiting their response. I hope they send me more." The other preservice teacher said that the problem sent to her made her look at different strategies for solving problems. She said that because the problem was sent by one of her student groups, it had lots of meaning to her.

The types of interactions selected as positive provided some insight into the preservice teachers' involvement in the e-mail activity. The three most prevalent categories of positive problems all directly involved what the elementary students wrote, rather than what the preservice teacher did in the activity. The personal communication aspect that the e-mail activity provided was valuable to many of the preservice teachers. After all, they chose the field of teaching because they enjoyed working with children. Through the e-mail activity they could learn more about the children in their groups. In the same way, if the elementary children

provided a good description of the process they used in solving their problems, the preservice teachers learned a lot about the skills, capabilities, and thinking processes of the children. Because these were the top two items selected by the preservice teachers, it was evident that one benefit of the e-mail activity was that the preservice teachers had the opportunity to interact with children.

Summary of involvement in the e-mail activity

Although each of the preservice teachers had different experiences as a result of their involvement in the e-mail activity, one major theme emerged after examining their views of their participation. It was evident that creating a meaningful experience for the elementary students was very important to most of the preservice teachers. Much of what the preservice teachers wrote about in their positive and problematic interactions reflected their desire to create a situation where students could expand their mathematical problem solving skills. The nature of their communications with their student groups, the feedback that was provided, and the types of problems that they chose indicated the preservice teachers' desire to make their participation meaningful. The preservice teachers used commercial resources to develop an understanding of the types of items that should be appropriate at different levels. It seemed more important to them to create a meaningful experience for the elementary students than it did for them to further prepare themselves to teach. However, the creation of meaningful experiences required lots of information about the students and their skills that the preservice teachers had to first obtain.

Authenticity of the E-mail Activity

Part of the reason for constructing the e-mail activity was to provide an authentic learning experience for the preservice teachers. It was not known, however, if an activity using telecommunications as a medium would be considered to be authentic by the men and women enrolled in this course. To develop a sense of their perceptions, the criteria developed by Myers were examined. Myers (1993) claimed that authenticity encompassed three criteria: the learner's perception of the activity as real or genuine, the learner's perception of

the activity as challenging and risky, and the learner's perception of the activity making a difference in their life. Each of these criteria was examined with respect to the six women who were interviewed.

Perception of realness/genuineness

It was difficult to develop a sense of how genuine the e-mail activity felt to the preservice teachers without having something to compare the perception to. Therefore, the field experience was discussed at some length during the interviews so that this comparison could be addressed. The preservice teachers were asked to rate both of these experiences on a continuum based on how real or genuine each felt to them. It was believed that the field experience *should* be considered to be more real than the e-mail activity since the preservice teachers had the opportunity to work in a classroom with actual students in a face-to-face setting.

The six case study participants responded very positively toward the e-mail activity in terms of helping to prepare them to teach mathematics. Their overall ratings of the activity were favorable, which in itself, indicated that the e-mail activity was worthwhile. The practicum was evaluated as slightly more real overall than the e-mail activity. The e-mail activity was not rated much lower than the field experience, however, indicating the degree of its impact on the preservice teachers. In fact, Lori rated the e-mail activity higher than the practicum in terms of realness, and Emily and Erin gave both activities the same rating. Figure 13 shows the ratings of both the e-mail activity and the field experience for the six case study participants.

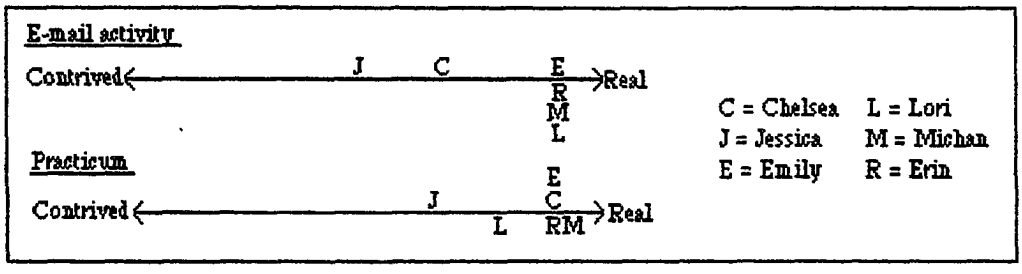

Figure 13. Realness ratings of the e-mail activity and the field experience provided by each of the case study participants.

There were several items contributing to the high ranking of the e-mail activity. One factor identified by the case study participants was that the activity gave them the opportunity to select their own problems and to see how the students reacted to them. Although the preservice teachers were uncomfortable with this role early in the activity, they learned how to discover what types of problems the students were capable of solving; this made the activity feel real to them. Unfortunately, the preservice teachers could not physically see the work that the elementary children did to solve the problems. They had to provide feedback based on the elementary students' messages alone. These were sometimes incomplete messages. Chelsea and Jessica felt somewhat limited by this aspect of the activity because they believed that their student groups could not effectively write about the process they used in formulating solutions. Chelsea and Jessica's realness ratings were lower than those provided by the other four case study participants as a result.

The e-mail activity and the practicum experience were rated as being equally real by Emily. She felt that the e-mail activity allowed her to develop an understanding of the characteristics of a good problem. By writing her own problems, she was able to see that it was not a simple task to create items to challenge students while at the same time being appropriate for their skill levels. She did not associate her perception of the activity as real in terms of her interactions with the students specifically, but rather in terms of her involvement in problem selection. She saw herself in a teaching role in this activity. In addition, because she had a large degree of success with the problems that she wrote, she felt that the e-mail activity helped her become more comfortable teaching mathematics and mathematical problem solving to elementary children. It was difficult to speculate if Emily would have reacted similarly if the problems she wrote were too difficult or too easy for her students. On the other hand, part of her success may have been attributed to her understanding of what her students were capable of doing.

Lori developed enough of a relationship with her student groups where she felt comfortable when they teased her and got somewhat sarcastic with her. She enjoyed checking her e-mail account for new messages because she was excited to see how her students solved the problems that she sent to them. She related her comments to things that the children wrote about–she knew she was not really their teacher, and yet she felt that what she wrote to them could have an impact on their perception of mathematics and mathematical problem

solving. This was an authentic experience for her because even though the children were far away, they were real kids. There was a purpose to her involvement in the activity.

Michan and Erin saw a connection between what they were doing in the e-mail activity and what they would be doing as teachers, so the e-mail activity was genuine for them as well. They both felt that the activity helped them find good problems for students to solve, and that it enabled them to see student difficulties with respect to problem solving. They were careful in their feedback so that they could help the students to develop their problem solving skills.

The activity as challenging, inspirational, empowering, and risk-taking

The word "challenge" conjured up different meanings for the preservice teachers. In terms of the e-mail activity, each of the six case study participants felt challenged to send appropriate problems to the students they worked with. They strongly felt that they would need to rely on the feedback provided in the messages written by the elementary student groups in order for them to understand the appropriateness of the items they sent. Beyond this, there were definite differences between the case study participants in terms of what it meant to be challenged.

At the beginning of the e-mail activity, Lori, Michan, and Erin all stated that they would need to determine good problems for their students. They believed, however, that it was within their capabilities to discover what was appropriate–it was just a matter of using student feedback to help them in subsequent selections. Their confidence in themselves and in their mathematical abilities helped them to know that they could assist students in developing their mathematical problem solving skills. Therefore, rather than being challenging, the activity was more empowering to them.

Jessica and Chelsea had more difficulty figuring out what would be a good problem for their student groups. In fact, Chelsea responded that she felt every problem she sent to her Virginia group was a challenge for her because she could not grasp the kinds of problems that were appropriate for them to solve. She was very uncomfortable with her role in choosing problems for her student groups.

Jessica believed that one of the challenges of the activity for her was in providing feedback to the students when they solved a problem incorrectly. Asking the students to go back and try to solve a problem a

second time was something that Jessica thought was very risky. She tried this only after several weeks of the activity, and it was not something that she was completely comfortable doing. It was likely that Jessica would have felt better about asking students to do this in a regular classroom situation where the students knew her better and where she also had a more clear understanding of the errors that commonly were made.

Emily believed that she took lots of chances by sending open-ended problems or items where she did not know the answer ahead of time. Since her own educational experience did not include problems of this nature, she was unsure of her capabilities to perform this type of task. Emily felt that she would have been less likely to use the problems that she sent to her e-mail groups with students in a face-to-face situation. In a face-to-face activity she would have to deal directly with their frustration levels if the problem was too difficult for them. In the e-mail activity, she was not there to deal with these frustrations and therefore felt that there was less risk involved in sending them. This sentiment was also echoed by Lori and Erin. The structure of the e-mail activity seemed to encourage at least some of the preservice teachers to take risks that they ordinarily would not attempt in a regular classroom situation.

Makes some difference in their life

There was a general consensus among the case study participants that the e-mail activity helped them get a sense of the mathematical and problem solving skills of students at certain grade levels. This was important since prior to the e-mail activity, they had a difficult time listing mathematical skills, other than computations, that their students should have. This was likely a reflection of their beliefs of what mathematics entailed. Even though they did not work directly with the elementary children as they solved the problems, the preservice teachers felt that they could develop an understanding of the children's mathematical and problem solving capabilities through electronic communications. For several of the preservice teachers, their experience working with children in the e-mail activity gave them another opportunity to learn about teaching mathematics, and since it involved real kids, they felt this was a valuable aspect of their participation. Many of them were able to work with children at two different age levels as a result of their placement in the practicum and their e-mail activity pairing.

In addition to some commonalities among the preservice teachers, participation in the e-mail activity also allowed for different areas of growth among the participants. Chelsea said that she learned that writing appropriate problems involved more than just putting computations into a word problem. She grew to recognize the importance of student feedback in terms of helping her evaluate the students' understanding. She had her boyfriend help her create several of her problems, so it made enough of a difference for Chelsea to include the activity in her personal life outside of school. Since her elementary groups did not write enough about their processes used, however, the value of the activity was not as high as it was for some of the other case study participants.

Jessica learned about children from areas of the country she knew little about. She gained an understanding of how to adapt her problems so the students could solve them, even if she was not there personally to help them. In addition, Jessica realized the limitations of the writing skills among third and fourth graders. She recognized her role as a teacher to help the students better develop their thoughts and ideas. Yet by the end of the activity, Jessica seemed to care less about her involvement than when she first began the activity. The activity seemed to become more of a requirement than a learning experience.

The e-mail activity made a difference for Emily in several respects. She gained confidence in her ability to not only write her own mathematical problems for students, but also in terms of teaching mathematics in general. Because she had such a high anxiety level toward the subject, Emily had many fears and apprehensions regarding teaching mathematics to elementary children. Her success in the e-mail activity, however, demonstrated to her that she had the ability to be an effective mathematics teacher. Even if the e-mail activity did not involve children working with her face-to-face, Emily believed that she developed an understanding of the approaches used by children when solving problems. She learned how to word her problems so that her student groups knew what she wanted them to do. The e-mail activity proved to be a very rewarding experience for Emily. She learned that her personal struggles with mathematics did not have to impede her success in working with children in mathematical activities.

Although many of the preservice teachers made revelations about their role in providing feedback and their comfort levels and expertise in writing problems for the students to solve, Lori was unique in that she

gained an understanding of her own problem solving process. As she read the responses from her elementary groups, she was forced to think about processes she had not considered using to address the problem. In addition, her initial feedback to wrong solutions was to try to prescribe her method of problem solving to the student groups. After realizing what she was doing, she changed her feedback to allow for more flexibility in the students' approach. The e-mail activity allowed Lori to understand and react to her own impulses to help in the development of problem solving skills in her students.

The e-mail activity helped Michan experience growth as well. One of the aspects of the activity that she felt was beneficial was that she learned how to explain things to children without directly showing them what to do. Because she could not be with the children in person as they solved the problems she sent to them, Michan had to compose messages that would help them understand what she expected. She did not have as much involvement in the activity as she felt was necessary to get a better sense of the students because of the weekly message exchange.

Erin also felt that the e-mail activity helped her learn how to teach mathematical problem solving to students. Because of the distance and the once-a-week communication, she had more time to think about her messages and her feedback. She speculated that she was more effective in helping the children develop mathematical problem solving skills as a result. Erin also commented that because she did not have to deal with discipline problems in her contacts with the elementary students, she was free to really focus on problem solving.

The overall improved consistency between the preservice teachers' ratings of the Problem Set items with the ratings of the participating teachers demonstrated that the e-mail activity helped the preservice teachers develop teaching skills through their involvement in the activity. This showed that participation in the e-mail activity, along with other class endeavors, made a difference in the preservice teachers' preparation for the classroom.

Overall evaluation

There were differences in the degree to which the criteria described by Myers (1993) were addressed by the e-mail activity. Table 11 summarizes the perceptions of each of the case study participants with respect to

Myers' categories. The criteria were evaluated using the degree of the participants' reactions in each of the categories.

The e-mail activity was rated favorably as a genuine activity by all of the case study participants. Chelsea and Jessica were not quite as positive, but still felt that the e-mail activity had aspects making it real to them. With respect to whether the e-mail activity was challenging or made a difference in their lives, there was variation among these case study participants. Overall, the activity was not considered to be as authentic as an experience where they worked directly with students in a classroom situation, but it still had much value and merit for those involved. The preservice teachers used disciplined inquiry to construct meaning about their elementary student groups and also about their abilities as teachers to help these students develop problem solving skills (Newmann & Wehlage, 1993).

Table 11

Myers' Authenticity Categories for the Case Study Participants

	Real or genuine activity	Challenging, risk-taking, empowering	Made a difference in their lives	Overall Degree of Authenticity
Chelsea	Moderate	High	Moderate	Moderate
Jessica	Moderate	Moderate	Low	Moderate
Emily	High	High	High	High
Lori	High	High	High	High
Michan	High	Moderate	Moderate	Moderate
Erin	High	Moderate	Moderate	Moderate

These results show the potential of e-mail activities linking preservice teachers with elementary students to be considered authentic learning experiences, according to the criteria established by Myers. However, there were other issues related to authenticity that emerged during the study that did not deal exclusively with the preservice teachers' perceptions of the activity as authentic. One of these items was the

general environment of the e-mail activity. The structure of the e-mail activity was that it was an environment where the preservice teachers could take on some of the functions that a regular classroom teacher would take: selecting problems, evaluating responses, and providing feedback. Several of the preservice teachers discussed their perception of the degree of control they had with the e-mail activity–indicating that control was a crucial element in the perception of authenticity as well. Myers' criteria only examined learner perceptions of the activity and did not look at the physical structure of the activity itself or how it addressed the discipline.

The examination of the criteria for authenticity as defined by Myers showed the value of further exploration of telecommunications-based activities, such as this e-mail activity, in the teacher preparation curriculum. There were also several items that emerged during the study that Myers' criteria did not address, suggesting that Myers' definition may not completely reflect the authenticity of a particular activity.

The Influence of Mathematical Anxiety on Involvement in the E-mail Activity

The degree of anxiety toward mathematics can be very influential in terms of the way teachers teach mathematics to their students. The literature indicates that teachers with high levels of mathematical anxiety spend less time overall on mathematics than teachers with a more positive attitude toward this subject area and that teachers with high levels of anxiety toward mathematics have been shown to involve students in more drill and practice activities and fewer problem solving activities than teachers who are less fearful of the content area (Conrad & Tracy, 1992). Because of these differences in regular classrooms, the e-mail activity was examined to determine if differences in involvement existed between preservice teachers with high and low levels of anxiety toward mathematics.

Implications of the Mathematics Anxiety Rating Scale scores

The overall mean on the MARS test for all of the preservice teachers enrolled in the mathematics teaching methods course was 225.96 at the beginning of the semester, with a standard deviation of 55.255. When the preservice teachers took the instrument at the completion of the semester, their overall mean score had

decreased to 204.346, with a standard deviation of 57.71. This twenty-one point difference in scores was significant, $t(25) = 2.61$, $p < .05$. These results are reported in Table 12.

Using the class' point differential of 21 as a standard, Jessica and Lori both had significant decreases in their level of mathematical anxiety as the semester progressed. Both Emily and Michan had scores that increased. Lori felt positive about herself mathematically from the start of the semester, so her decreased score was not nearly as interesting as Jessica's. Jessica strongly believed that she felt much more comfortable with mathematics as a result of the methods used in the course. She felt that the hands-on, manipulative-based approach used in the class helped her grow not only as a teacher, but also in terms of her own understanding of mathematical concepts. This was consistent with Sherman's research that suggested manipulative-based mathematics courses can help preservice teachers better understand mathematical concepts that had not been comprehended by them very well earlier (1992). Jessica's decrease of 71 points on the instrument reflected her improved outlook of mathematics and also her new confidence in teaching the subject.

Table 12

Change in MARS Scores from the Beginning of the Semester to the End of the Semester

	MARS-pre score	MARS-pre *SD*	MARS-post score	MARS-post *SD*	Change in MARS score
Class Overall	225.96	55.255	204.346	57.71	- 21
Chelsea	330		316		- 14
Jessica	306		227		- 79
Emily	296		324		+28
Lori	132		108		- 24
Michan	123		144		+21
Erin	123		112		- 11

Michan and Emily had MARS scores that increased between the first administration and the second testing. Michan's increase could be explained as a natural regression toward the mean. Although her score increased by twenty-one points between the first and second administration of the test, she still had one of the four lowest anxiety scores in the class. Emily's increased score was more cause for concern, especially since it seemed inconsistent with what she said about herself in the interviews. Emily felt that she gained a lot of confidence in herself and in her ability to teach children mathematics as a result of the mathematics teaching methods course and also directly as a result of her participation in the e-mail activity. It is possible that her increased score was a result of being more honest when completing the instrument the second time.

An interesting observation regarding the three women with high mathematical anxiety levels was that they blamed their mathematical inadequacies primarily on their secondary teachers. They all said that their teachers were not able to reach them or to help them understand mathematical content. The three participants with low mathematical anxiety levels talked specifically about their teachers being able to teach in ways that helped them to learn mathematics. The NCTM's approach to teaching mathematics is based on principles of constructivism, where teaching is student-centered rather than teacher-centered. It is certainly possible that even in constructivist-based classrooms, teachers may be unable to provide students with experiences to help them understand mathematical content. The fact that all six of the case study participants either attributed or blamed their success or lack of it on their teachers suggests that they did not think of mathematics teaching from a constructivist perspective early on in the semester. They did not talk about activity- or manipulative-based curriculums, but rather that their mathematical skills came directly from their teachers. It was interesting that the level of mathematical anxiety did not affect this perception.

Feedback provided to the elementary students

The type of feedback that the preservice teachers provided to their student groups for both correct and incorrect responses seemed to be directly influenced by their level of mathematical anxiety. The three case study participants with high levels of mathematical anxiety did not refer to specific items that the elementary students wrote in their message when they responded to their student groups. Their responses were rather dry in that they

methodically explained what should have been done or they simply told the students that their solution was correct without further reinforcement.

The three case study participants with lower anxiety levels focused their feedback much more on the actual processes that the elementary students used in solving the problems. Regardless of whether the students had correct or incorrect responses, these preservice teachers referred to the messages written by the elementary students in their feedback. Because these three future teachers were confident in their abilities with respect to mathematics, they felt comfortable analyzing what the elementary students had done to formulate their solutions. Providing feedback of this nature can greatly facilitate the growth of problem solving skills. The structure of the e-mail activity did not enable the case study participants who had high levels of anxiety toward mathematics to go beyond their levels of comfort to assist children to the same extent as the case study participants with low anxiety levels.

Problems sent to the elementary students

The types of problems that the preservice teachers chose to send to their student groups were influenced by many factors. One of those factors may have been their mathematical anxiety levels. Although it was nearly impossible to completely base findings on anxiety levels alone, trends were found relating the types of problems sent and mathematical anxiety levels. This issue was examined by looking at several factors: the success of the preservice teachers in determining the mathematical and problem solving abilities of their student groups, the types of problems that they sent to their student groups, the quality of the problems that they sent, and the sources that they used in locating their problems.

Determining the skills of the elementary children. All of the preservice teachers were somewhat uncomfortable with understanding the skills and abilities of their elementary student groups at the beginning of the e-mail activity. The difference that the anxiety level made, however, was that the preservice teachers with higher anxiety levels took longer before they felt that they understood the skill levels of their students. This was based not only on the number of weeks before sending problems that their students could successfully solve, but also on their responses to interview questions regarding their student groups. The preservice teachers

with low mathematical anxiety levels believed that they figured out what would be appropriate for their student groups after one or two messages had been sent. They were better able to adjust their problems to their students than were the preservice teachers who exhibited higher levels of mathematical anxiety.

Types of problems sent. The preservice teachers with high levels of anxiety generally were more comfortable using commercial problem solving resources than they were with creating their own problems from scratch. Emily was an exception to this tendency. Jessica and Chelsea did not feel confident writing their own problems since there was no feedback for them to know if what they wrote was at an appropriate level for their students. Using commercial resources did not make them totally comfortable but it gave them more confidence than creating a problem from scratch.

The case study participants with low mathematical anxiety levels were more likely to feel confident about their problem selections, regardless of the sources they used to select them. They seemed to have a better understanding of what was appropriate for their students, and were able to make a good selection based on what they knew about their student groups. They experimented with different problem solving genres more than the preservice teachers with higher anxiety levels. They viewed the problem selection as a challenge, yet something they could handle.

Quality of the problems. Correlations between the mathematical anxiety level and my ratings of the problems during weeks three and week nine were examined. At week three, the correlation coefficient describing the relationship between mathematical anxiety and the rating of problems was $r(25) = -0.326$. This score indicated that preservice teachers with a high score on the Mathematics Anxiety Rating Scale tended to send problems that met fewer of the characteristics of good problems as defined by the NCTM. At week nine, the correlation coefficient measuring the relationship between the MARS score and the problem rating was $r(25) = -0.019$–nearly no relationship existed between anxiety levels and the quality of the problem sent. This was significant in that it indicated that the e-mail activity allowed for the growth of the preservice teachers who had less confidence in their mathematical abilities. By the end of the e-mail activity, the preservice teachers

with high anxiety levels toward mathematics were sending problems that were similar in quality to the problems sent by the preservice teachers with low anxiety levels toward mathematics.

Sources used. It was difficult to detect trends in the sources used to select problems to send among the preservice teachers with high and low levels of anxiety toward mathematics. All six of the case study participants drew from commercial resources such as the TOPS decks and elementary mathematics textbooks at some point during the semester, especially early on in the activity. Five out of the six case study participants created their own problems at some point during the semester. All three of the low anxiety participants wrote their own items, while Jessica was the only high anxiety participant who did not attempt to write any of her own items. Unlike Jessica, however, Emily and Chelsea both wrote a large number of problems from scratch. Although it was thought that the preservice teachers with high mathematical anxiety levels would rely heavily on commercial sources to collect their problems to send to the elementary students, this was not the case. The six case study participants used a variety of sources to create their problems, regardless of their mathematical anxiety levels.

Overall analysis of the effect of mathematical anxiety

The level of mathematical anxiety had less of an effect on participation in the e-mail activity than was speculated. Although there were some initial discrepancies in performance with respect to the quality of problems sent to the student groups, by the end of the activity, this difference was negligible. The overall quality of the problems was lower than was hoped, however, and this fact could have contributed to fewer differences between the two groups.

There were still some differences based on anxiety level. The quality of the feedback provided to the elementary student groups was definitely much higher among the preservice teachers with low mathematical anxiety levels. This group was much more willing to carefully examine the processes used by the elementary students to help them develop better problem solving skills. The preservice teachers with high mathematical anxiety levels provided their feedback more independently of the process used by the elementary students. The preservice teachers with high levels of mathematical anxiety were also much more likely to be concerned about

whether the elementary students were able to formulate correct solutions to the problems they were sent–to the extent that they were willing to send them items that did not match their own criteria for what a good problem entailed. The preservice teachers with lower anxiety levels were more content to examine the processes used by the students to observe growth in problem solving skills. They were much less concerned about the actual answers.

Another difference based on the levels of mathematical anxiety was in understanding the abilities of the elementary students. High levels of mathematical anxiety seemed to cause the preservice teachers to take more time to evaluate the skills of their student groups. The amount of frustration early on in the e-mail activity also seemed to be related to the amount of mathematical anxiety. Chelsea and Jessica were less successful in sending appropriate problems to their student groups than were the preservice teachers with low anxiety levels. This seemed understandable given that mathematical problem solving was intimidating to the three case study participants with high MARS scores and also that their mathematical backgrounds were poorer to begin with. As with the quality of problems sent to the elementary student groups, there were fewer differences related to anxiety levels with respect to knowing the skills of the elementary students by the end of the e-mail activity.

The preservice teachers, regardless of their anxiety levels, all felt that they learned a great deal through their involvement in the e-mail activity, especially regarding selecting quality problems at appropriate levels for their students. Beyond that, however, the nature of what they felt they learned differed based on their attitude toward mathematics. The preservice teachers who had high levels of anxiety seemed to focus on generalities that they learned as a result of the activity. They felt that they learned about using electronic communications, for example. They also believed they learned about the skill levels of the elementary students. The preservice teachers with lower anxiety levels were more focused on how their actions helped or hindered the development of mathematical problem solving skills among the elementary children in their groups. For instance, they suggested that they learned not to provide feedback so specific as to channel the children into a certain process. They commented that their language had to be clear enough for the students to know what was expected. The preservice teachers with low mathematical anxiety levels seemed more prepared to take on the role of "teacher" in terms of helping children develop mathematical problem solving skills.

Given these factors, there was evidence that telecommunications activities can assist preservice teachers with high mathematical anxiety levels in their preparations for teaching. Initial differences with respect to anxiety levels seemed to be less noticeable at the end of the ten-week communications. Although the e-mail activity was not completely unstructured, there was enough flexibility to allow the preservice teachers the space to accommodate their personal needs. For the preservice teachers with high mathematical anxiety levels, this meant that they needed some time to develop a level of confidence with respect to their role in the activity. Once they had established this comfort level, there were few differences in how they reacted to the e-mail activity.

Electronic Communications in the Teacher Preparation Curriculum

The preservice teachers involved in the e-mail activity were asked to write about their reactions to the e-mail activity as a whole, both positive and negative, after the completion of the e-mail activity. They were also asked to reflect upon what they felt they learned from the experience, if anything. For many preservice teachers, the positives and what they felt they learned were intertwined. Their opinions regarding what they felt they learned and the limitations of the medium, along with the other data collected, suggest the value of using electronic communications to help prepare elementary teachers.

Benefits of the e-mail activity

Several items were mentioned as being positive learning experiences as a result of the e-mail activity (see Figure 14). One of the items the preservice teachers mentioned was that the e-mail activity helped them become more familiar with using electronic mail. Most of the preservice teachers had used electronic mail in other education courses prior to the mathematics teaching methods course. However, in the e-mail activity, they expanded their skills to include aspects of electronic mail that they had not previously encountered. For example, they learned to carbon copy messages, file mail, create mailing lists, append messages, and copy and paste.

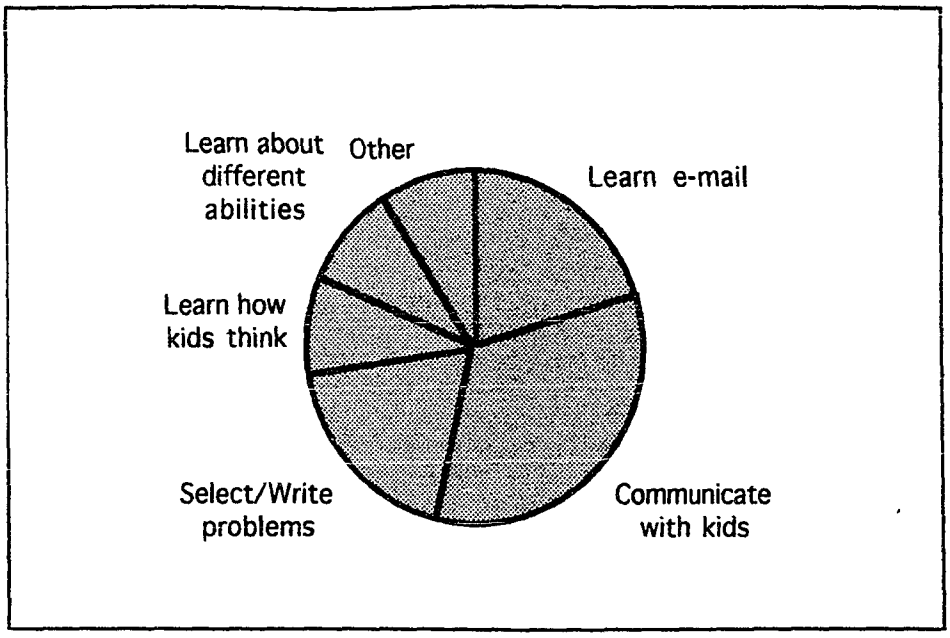

Figure 14. Preservice teachers' choices as benefits of the e-mail activity.

In addition to improving their e-mail skills, the preservice teachers also said that their involvement prompted them to think about ways of integrating the technology into their curriculum. They were able to see how using electronic communications could be a powerful teaching tool. One preservice teacher said, "I enjoyed seeing how an e-mail interaction would take place...I can see how students could benefit in many ways from interacting with others in different parts of the United States/World." Bishop-Clark and Huston suggested that it was more likely for new technologies to be used by teachers if they worked with the technologies in their teacher preparation programs (1993). Because of their perception of the e-mail activity as a genuine activity, the preservice teachers viewed the use of telecommunications as valuable to their own future curriculums. This was certainly a start in the right direction. Since this was not a technology course, this was a very positive result.

Communications with elementary students was also listed as a positive aspect of the e-mail activity. The participants commented that it was fun getting to know the students and learning about their interests and skills. Many of the preservice teachers enjoyed making comparisons of the skills, attitudes, and interests between their two student groups, especially since the groups were from diverse areas of the country. These

differences allowed the preservice teachers to understand that not all children were at the same level, despite being in the same grade. One preservice teacher made the following remark:

> I think that this assignment showed me that each student is different and you can tell this without seeing or openly conversing with the students. One of my groups wrote really short and concise messages, while the other was more personable and concerned about explaining their solutions and reactions. This is just one way that I saw differences in the groups and it reinforced to me that I need to appreciate each student, regardless of whether they match my own style.

It is important for teachers to recognize that they are teaching not a class of twenty-five children but rather a group of twenty-five individuals. Although the elementary students worked in groups in the e-mail activity, the preservice teachers still developed a sense of the differences that exist between people.

Finding, writing, and evaluating good, challenging mathematics problems benefited many of the preservice teachers. They felt that they learned how to write good problems based on the abilities of their students. They also realized how difficult this task was. They felt that they developed a collection of valuable resources for problem solving activities as a result of their searches.

The preservice teachers believed that they developed an understanding of the capabilities of elementary children with respect to mathematics and mathematical problem solving through their involvement in the e-mail activity. Despite their early feelings of uneasiness about understanding what their student groups were capable of doing, the preservice teachers felt that they had a clear conception of what their student groups could solve by the end of the e-mail activity. It was likely that in-class activities in addition to the e-mail activity itself contributed to this understanding. However, the preservice teachers specifically singled out their involvement in the e-mail activity as helping them know what to expect from their own future students.

The preservice teachers were amazed by the capabilities of the elementary students. Because they were motivated to do well, the elementary children often surprised the college students not only with a correct solution to a complex problem, but also with an impressive explanation of their process. This was very eye-opening in many cases. Because the e-mail activity was a long-term project, both the preservice teachers and the elementary students could develop their skills through their involvement in the activity.

The e-mail activity helped some of the preservice teachers learn to word problems clearly so that the children understood what was meant in the item and also in the feedback. One future teacher wrote, "I learned to

say what I want in as few words as possible and as clearly as possible." Another said, "It was challenging to explain just through print without the help of visual aids, nonverbal cues, vocal inflection, but it really made me hone my explanation skills because I needed to choose specific words that they would understand just by reading them." There are times when "less is more", and several of the college students recognized this quality.

Clear communication not only affected whether the elementary students understood what to do, it also influenced how well the preservice teachers could respond to the elementary students. If the elementary students did not write about their process clearly, it became difficult for the preservice teachers to not only provide useful feedback but also to learn about the thinking processes of elementary children. One of the preservice teachers claimed that having the children write about the problem solving process was important to her for two reasons, "The first of which is that when I respond to their solutions I can tell them where they may have made a mistake. The second reason that this was beneficial is because students were showing me that they understood the concepts and not just an algorithm." Several of the mathematics teaching methods students concurred that the e-mail activity helped them see the importance of understanding the process instead of simply providing a correct answer to a problem.

Limitations of the e-mail activity

There were several limitations of the e-mail activity listed by the preservice teachers who participated in the communications (see Figure 15). Although the on-going contact with the student groups was listed as a positive element of the e-mail activity, many of the preservice teachers felt limited by the once a week communication structure. They felt their feedback would have been more helpful had more communications occurred. Providing feedback to incorrect responses was particularly troublesome because of the once weekly messages. Since so much time had passed between when the students solved the problem and when they received feedback from their college partners, the preservice teachers did not know if there would be much value in having the students try to solve the problem again. Harasim found that the medium of electronic communications can cause confusion about whether a topic should be addressed more or if it had been overtaken by another theme, such as a new problem to solve (1990). If electronic communications becomes a part of teacher preparation programs, this issue will need to be addressed.

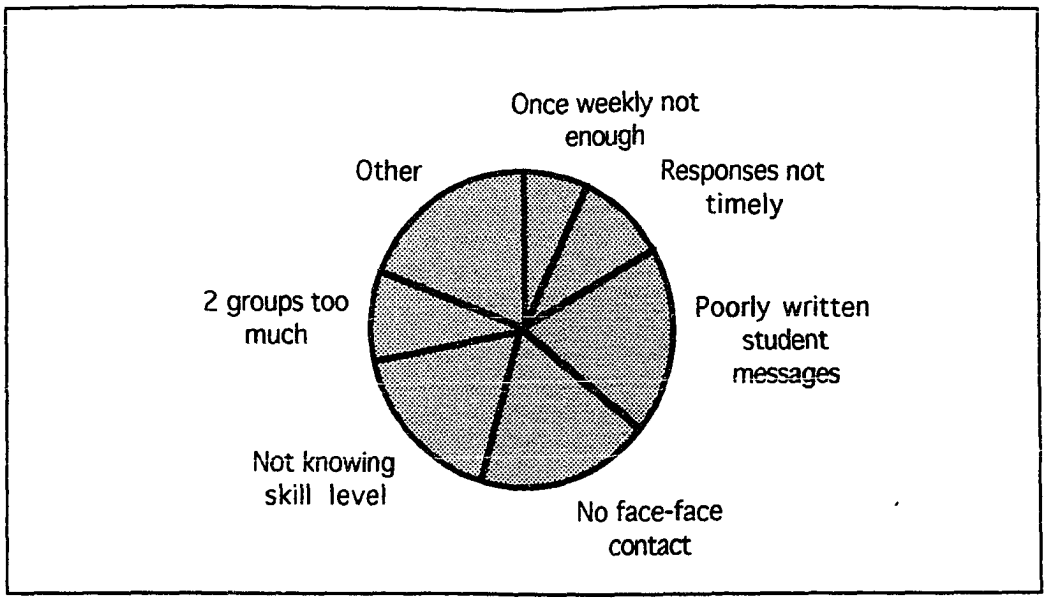

Figure 15. Preservice teachers' choices as limitations of the e-mail activity.

Sometimes the elementary student groups did not respond in a timely fashion to a problem that was sent to them. This caused some distress among the preservice teachers. They were not sure if they should go ahead and send a new problem (since the course requirements indicated that they needed to send one problem per week) or if they should wait until they received a response from their students before sending a new one. In addition, the preservice teachers who experienced this situation felt it was extremely difficult to know what was a good problem to send to their students without this gauge. Telecommunications-based activities need to be constructed to address this limitation.

Another negative aspect of the e-mail activity for some of the preservice teachers was how much effort the elementary students put into solving the problems and formulating their responses. Because the college students were not present when the elementary students solved the problems, they did not know for certain how much effort was put forth–they could only develop a sense of how much the students' labored based on the responses received. If the students did not have the ability to solve the problem, their response may have been poorly worded and misinterpreted as a lack of effort instead of a lack of ability. There was also the potential for

there to be a difference between what the children did and what they said they did. The preservice teachers may have had a better sense of these factors had they been able to actually observe the children work through the problems. Although this did not occur in the e-mail activity in this study, further growth of telecommunications technologies may make this limitation less of a factor.

Observing the children was actually a very important element for many of the mathematics teaching methods students. The e-mail activity did not allow them to be with the children in a face-to-face manner. As a result, some of the preservice teachers felt that they did not really know the children well, nor did they develop a good understanding of what the students did to solve the problems. They could not listen as the children explained their thinking–and sometimes the written descriptions did not depict their process as well as they could have using visuals or verbal communication. In addition, the preservice teachers could not monitor the use of manipulatives to assist in understanding. The preservice teachers desired to be more closely involved with the students as they solved the problems.

In addition, because the preservice teachers were not present when the students solved the problems, it meant that the classroom teacher needed to deal with any student questions. Several of the preservice teachers commented that a negative aspect of the activity was that they did not get to fully carry out the responsibility of the teacher if the students did not know how to solve the problem; that if the students did not know how to progress, they asked their classroom teacher for help rather than asking the college student. Their role as a teacher, then, was only partially fulfilled through the e-mail activity. They did not have the extended follow-up contact that a regular classroom teacher would have.

Comparison of the e-mail activity to the field experience

The preservice teachers were asked to briefly discuss their field experience and, if they could, compare the e-mail activity to their practicum. Asking them to complete this task provided some perspective about what they felt was important in terms of their preparations to become a teacher. It also helped to point out aspects of the field experience that could not be facilitated through the telecommunications medium.

Based on the preservice teachers' responses, it was clear that a good field experience was important and helpful to them. The preservice teachers felt that they learned a lot from being in the classroom and from

working directly with both teachers and students. Seeing the children work with manipulatives and explain their thinking processes helped the preservice teachers in their preparations to someday teach mathematics. There was also a general consensus among the preservice teachers that although they were only in the classroom one morning or afternoon a week for seven weeks, they developed a deeper relationship with the children than what they could do in the e-mail activity. One college student commented:

> I feel my practicum was beneficial to me because I was actually in the classroom and dealing with all the things that come up in the classroom. I got to observe that the children were really learning something from me. I did not feel this way with the e-mail children. I don't know if I taught them anything, although I hope I did.

The preservice teachers could get direct feedback from the children in their practicum, and this made it a beneficial experience to them:

> As great as this activity [the e-mail activity] was, I do not think it gives you even close to the amount of experience one gains from a good block [field] experience. I have been fortunate and have been allowed to teach every time when I go to my classroom. When you are teaching in a classroom, one has to be spontaneous and has to respond to the student as soon as a question is asked. For e-mail, you can answer whenever you want. Another big difference was that for e-mail, we were not really teaching them specific math skills besides problem solving. In block we have to teach them more math ideas and work with manipulatives, and make sure they are understanding the math vocabulary.

Several of the college students felt that they did not actually *teach* in the e-mail activity and were rather in a somewhat different role. This particular preservice teacher felt that problem solving was not a specific skill.

There was a wide range in the amount of mathematics and mathematical problem solving observed during the preservice teachers' field experiences. Some of the college students were paired with teachers who felt that problem solving was an important aspect of their curriculum. These preservice teachers could compare the kinds of skills exhibited by the students in their practicum with those of the students in the e-mail activity. On the other hand, some of the preservice teachers were placed in classrooms where there was little emphasis on problem solving or even on mathematics. Several mathematics teaching methods students commented that they received more experience with problem solving in the e-mail activity than they did in their practicum. One preservice teacher wrote, "As far as my practicum goes, I was accidentally placed in a language arts time period, so I didn't see a whole lot of math, if any, while I was there. This e-mail project was the only experience [with mathematics] I found that I really received." Another preservice teacher said, "In comparison to my practicum, I received much more experience in math [through the e-mail activity] than I am receiving in math and science

combined in my practicum. Most of the time I do not even observe math or science in my practicum. Overall, I have been very disappointed in my practicum." The purpose of the practicum was for the preservice teachers to be placed in classrooms where they could observe mathematics and science in an elementary classroom, as well as to teach a lesson in each of these subject areas. When this did not become a reality, participation in the e-mail activity was able to give the preservice teachers at least some direct experience working with elementary children in a mathematical environment.

Another comparison made by several of the preservice teachers dealt with the grade levels of the students in the e-mail activity and the students in their practicum experience. Many of the college students were placed in early elementary classrooms in their field experience, while most of the elementary students involved in the e-mail activity were at the upper elementary grades. One of the preservice teachers wrote the following message.

> Personally, I have always felt that there is no substitute for direct, personal experience. In this case, however, both experiences were equally beneficial. Why? Because this e-mail activity involved working with 5th grade students, and therefore, I gained experience in selecting math problems appropriate for this grade level. On the other hand, my practicum experience involved working with kindergartners. I have learned a great deal from this as well, because their cognitive abilities at solving math problems are vastly different than 5th graders'. Honestly speaking, since I am not an ECE [Early Childhood Education] major, I will probably not end up as a kindergarten teacher. Therefore, this e-mail activity was especially beneficial to me!

Most of the college students who were Early Childhood Education majors commented that they still enjoyed the e-mail activity, despite working with children at the upper end of what they would be certified to teach, because they learned about older children. They also claimed that working with older kids helped them better understand the kinds of activities they should have younger students perform to help prepare them for what they would be expected to do when they progress to higher grades.

This sentiment was not universal among the ECE majors in the class. One person preparing to work with these young children wrote, "I don't feel like I got much out of the project based on mathematical knowledge of the students I will teach, but I did learn more about e-mail and math processes in general. The kids were pretty fun to work with, too, which made it nice." This preservice teacher felt that she did learn as a result of her participation in the e-mail activity; however, she would rather have had more experiences working with the level of children that she would be specifically certified to teach. Because of the structure of this

particular e-mail activity, it would have been difficult for children much younger than third or fourth grade (unless very advanced) to write about their thinking processes in a way that would have benefited the preservice teachers. The preservice teacher who made this particular comment was paired with fourth graders from Virginia and also a group of fifth graders in a low mathematics group from New York. She was careful to send both of her groups problems where they could be successful, yet challenged, and her communications with them were very warm, friendly, and encouraging. Although she did not feel that the e-mail activity helped her very much in her teaching preparations, she was still professional enough to provide wonderful opportunities for the children in her groups. This particular college students' MARS score showed that she had low anxiety toward mathematics, so her comments were likely influenced completely by her belief that working with younger students would have been more helpful to her.

One of the preservice teachers wrote a particularly long reaction to the e-mail activity. She made several interesting comments in her message regarding what she learned through her involvement in the e-mail activity. This was one part of her message:

> When I compare the practicum to the e-mail assignment, this is what I find. I think that I know a few students' abilities in my practicum, but I have not had enough experience to really know the students there. The people that I e-mail are in groups, so I really don't know them individually, but I know better about what kinds of problems they will like and be challenged by. I think that it is easier to be objective with the e-mail groups because I do not have any experience with their behavior, or other background information that I might obtain in a school setting. In my practicum, my teacher did not come out and tell me information about particular students, but some of the bad behavior of certain students makes teaching difficult and influences teachers about the student. When you think about it, the e-mailing is really objective, which is a real strength. I think that it would be interesting to see how the students in my practicum would react to the e-mail problems. I bet that some of the students who are always reprimanded for their behavior and have a negative attitude in class would be some of the really good groups in the e-mail project.

Although the preservice teachers had pictures of the elementary students in their groups, they really did not, as this preservice teacher suggested, know the students on an individual basis. The students' problem solving capabilities were not limited by beliefs that the teacher had about their skills. Although teachers want to be fair and objective in working with children, behavior often influences the way they work with students. As this college student suggested, it was possible that the e-mail activity helped decrease this factor, and may even create empowering environments for the elementary students.

The intent of constructing the e-mail activity was not to replace the field experience that accompanied the class. However, it became very evident as a part of the research for this study, that many of the preservice teachers were not satisfied with their practicum placements. They were very interested in working with children and in learning how to teach mathematics, but they were at the mercy of their cooperating teachers in terms of how much experience they had with the children in a mathematical sense. Also, many of them only had a total of five face-to-face contacts with their students in the field placement. They felt that this was not enough. The e-mail activity helped to fill in some of the gaps that the field experience alone did not provide for many of the preservice teachers. Certainly it could never be a substitute for direct experiences with children, but prior to student teaching, it would seem beneficial to provide as many different opportunities to work with kids in an education setting as possible.

Summary

The e-mail activity provided an opportunity for the preservice teachers to select or write mathematical problems appropriate for a specific group of children. This was often a difficult task, especially at the beginning of the activity before the college students developed a good understanding of the skills of the students in their groups. The preservice teachers felt, however, that they eventually developed this understanding, and were able to choose appropriate problems by the end of the e-mail activity.

Although the preservice teachers listed characteristics of what they felt were good problems, they did not always use their definitions when it came to sending items to their groups. There was a relatively small number of real-life problems sent to the children, despite the agreement that these kinds of problems were very good ones for the children to solve. The number of items that were simply computations remained fairly stable throughout the e-mail activity. There was some overall improvement of the problems with respect to their compatibility with the NCTM Standards. By the end of the e-mail activity, the preservice teachers with high levels of mathematical anxiety were sending items to their student groups equal in quality to problems sent by their low anxiety counterparts.

The e-mail activity provided an environment for the preservice teachers to develop an understanding of the cognitive capabilities of elementary children. Because the elementary student groups wrote about the processes they used in solving the problems, the preservice teachers learned about how kids think and reason. Unfortunately, some student groups were better at writing about their methods than other groups. Not all of the preservice teachers gained the same depth of understanding as a result. Even when they were unable to learn much about how the children solved the problem, they discovered how important it was for children to be able to explain their reasoning.

Providing feedback to the elementary student groups proved to be very challenging for many of the preservice teachers, especially when the elementary students solved a problem incorrectly. The preservice teachers were not provided with much guidance in terms of helping them know what to say to their student groups, and therefore the responses varied widely. Some preservice teachers' feedback just informed the elementary groups if they were right or wrong, and nothing else. Some of the preservice teachers explained why the student response was right or where they made a mistake. Some of the college students provided hints to the elementary students to help them go back and try the problem again. Despite the variability in feedback, it was clear that the preservice teachers were uncomfortable providing feedback for incorrect answers.

The preservice teachers felt good about their participation when they were able to select problems that were at appropriate levels for their student groups. They enjoyed the personal communication from the students. They also enjoyed learning about the thought processes of children as they worked through different problems. The activity helped the preservice teachers realize their role in helping children to develop problem solving skills.

The e-mail activity had negative aspects as well. The preservice teachers were frustrated when they were unable to send problems that were at a good level for their students. They also felt limited by the explanations provided by the elementary students at times. If explanations were incomplete or missing altogether, the preservice teachers had to guess about the process that was used, and try to base their feedback on their guesses. They realized that through the e-mail medium alone, the students could not show drawings or use

manipulatives to help explain their processes to the preservice teachers. They could also not easily ask follow-up questions that might help to clarify what the elementary students did.

The overall reaction to the e-mail activity was quite positive. Although the preservice teachers felt that the activity was not a replacement for a field experience, they believed that it expanded their learning opportunities. This was especially true for several of the preservice teachers who had field experiences in classrooms where they observed only limited mathematics and those who were placed at a grade level that they were not interested in someday teaching. The activity helped them to learn a variety of things. Although the degree to which the criteria for an authentic experience varied from person to person, it was clear that the e-mail activity addressed the authenticity aspect of constructivist environments.

The messages written by the preservice teachers were generally very positive regarding the e-mail activity. Most started with quotes such as, "I really enjoyed doing this e-mail assignment," "The e-mail activity was interesting for me," "I felt this was a good opportunity for me," and others. Because there were a variety of different age levels and skill levels present among the elementary student groups, the experiences that the preservice teachers received varied greatly. And certainly not all of the college students learned the same things as a result of their experience. However, their comments demonstrated that learning did occur, and that the activity was considered to be an authentic learning experience. This is an important consideration in terms of using electronic communications in the teacher preparation program. It seemed that the e-mail activity in this study had enough merit to warrant continued exploration.

CHAPTER VI. DISCUSSION, RECOMMENDATIONS, AND CONCLUSIONS

This chapter presents a discussion of the results. The results are presented and discussed, followed by suggestions for further research. Finally, concluding remarks are offered.

Discussion of Results

An examination of the research questions of the study provided a relatively complete picture of the involvement of the preservice teachers in the e-mail activity. Individually, the research questions addressed the views of preservice teachers concerning their participation in the project. In sum, the research questions depicted the value and worth of a telecommunications activity as a part of the teacher preparation program. Much was learned in the study with respect to the involvement of the preservice teachers, their view of the activity as authentic, and the influence of mathematical anxiety on aspects of their participation. This information contributed to conclusions regarding the design of telecommunications activities for teacher preparation programs.

The preservice teachers' involvement in the e-mail activity

Several aspects of the preservice teachers' involvement in the e-mail activity were examined in order to gain an understanding of their views of their participation. The problems sent, the feedback provided, and both positive and problematic interaction selections all provided insight into the preservice teachers' perceptions of the activity. Each of these elements provided important information regarding the value, benefits, and limitations of the e-mail activity.

One of the items examined in detail was the general nature of the problems sent to the elementary students. Several interesting points emerged with respect to this topic. The preservice teachers were aware of the NCTM's criteria for quality problems. This was evident in both their descriptions of a quality problem and also in their ratings of a Problem Set. When selecting items to send to their student groups, however, the preservice teachers did not always make selections consistent with what they believed to be a quality item. For

example, their selected items were often computations put to words rather than real problem situations. In addition, few of their items involved problems allowing for more than one solution.

This inconsistency between their beliefs and their practices was not surprising because the qualities of good problems were often qualities not found in the types of problems the preservice teachers solved when they were elementary and secondary students. Since the preservice teachers were uncomfortable not only in their role in the e-mail activity, but also with the role of being a teacher in a mathematics environment very different from their own past experiences, they sought comfort in familiarity. In addition, they may have needed to grow from experiences sending low quality items before they could completely understand and feel comfortable sending better problems. Vygotsky's zone of proximal development suggests that learners can better understand matter when prompted by an expert than they can on their own (1978). Further, once this dialogue has been established, the learner can reflect on the dialogue and reformulate their own thought (Taylor, 1993). Participation in the e-mail activity provided the opportunity for this dialogue to commence. As they continued to have experiences in classrooms while student teaching and eventually in their own classrooms, the dialogue that they began during the e-mail activity can continue.

In addition, the structure of the e-mail activity may have also contributed to this inconsistency between qualities defined by the preservice teachers and the problems they chose to send. The preservice teachers only communicated with their student groups once weekly for the duration of the e-mail activity. This made it difficult to provide the kind of guidance that problems more consistent with the NCTM's criteria often require. Also, because the preservice teachers did not always develop a solid understanding of the skills of the elementary children, they may have believed that their student groups were not capable of solving the types of items that they believed would contribute to problem solving skill development.

It is questionable whether the preservice teachers would have selected better problems if the activity had taken place in a real classroom rather than via e-mail. Several of the preservice teachers indicated that because they did not have to deal with discipline problems or student questions in the e-mail activity, they were more likely to send the types of problems suggested by the NCTM within the structure of this particular project. Lack of confidence in their ability to respond to student questions caused the preservice teachers to be content

sending items that did not address their stated criteria for quality items. Their own experiences as students did not prepare them to help children develop problem solving skills, so for many preservice teachers, solving mathematical problems was not a familiar exercise–and trying to teach skills in that area was even newer to them. Although it is unfair to expect preservice teachers to respond as experienced teachers would in such a project, it is important to consider these aspects in future e-mail activities.

Because solving mathematical problems was a rather unfamiliar endeavor to the preservice teachers, they initially relied heavily on commercial resources to help them make their problem selections. This was not very surprising since these resources at least provided the preservice teachers with guidelines about what might be appropriate for their student groups. Several of the preservice teachers became comfortable enough to eventually write and send their own problems. The results of the e-mail activity indicated that comfort levels were a key factor in the types of problems selected. As the preservice teachers learned more about the skills of their students groups, their own confidence increased. As this confidence increased, their reliance on commercial problem solving resources decreased. If the preservice teachers were to go directly into real classrooms without experiencing a problem solving environment similar to the e-mail activity first, it is speculated that the results would not have been different. The preservice teachers needed time and experience to develop the confidence required to help children develop the problem solving skills advocated by the NCTM.

The overall quality of the problems sent by the preservice teachers increased somewhat as the e-mail activity progressed. In addition, there were fewer differences on the Problem Set ratings between the preservice teachers and the participating teachers at the end of the e-mail activity than at the beginning. These were positive outcomes of the project. The preservice teachers learned about the skills of their elementary student groups during the semester. As they learned about the capabilities of their groups, they were better able to determine if an item would be appropriate for these children to solve. Although they did not rate the Problem Set items exactly as the participating teachers did, the ratings were more consistent at the end of the semester than at the beginning, an indication of progress. This was a positive development of the relatively short duration of the e-mail activity.

It was difficult for the preservice teachers to provide feedback to the elementary students in the e-mail activity, especially when the solution to a problem was incorrect. One reason for these difficulties was that some of the elementary students did not always clearly write about the processes they used in solving their items. Without a solid understanding of the process used by the elementary students, the preservice teachers did not know how to respond to correct or incorrect responses. They could only reply to the correctness of a response rather than providing more detailed feedback that might help the elementary students develop better problem solving skills.

These items demonstrated the importance of constructing e-mail activities where communications is the key element–including the communication by the elementary students. Since there is no other contact between participants, the written communication becomes the only method of understanding each other. Classroom teachers need to address this aspect of the activity prior to making a connection with others. Since the NCTM Standards stress the importance of the communication of mathematical understanding, developing this skill more fully serves two purposes.

Another related shortcoming of the e-mail activity regarding feedback was that the structure of the once weekly communications did not foster an environment that encouraged the elementary students to re-work incorrect responses. The time lag between when the problem was initially sent and when the students received feedback was sometimes over a week. This was too long for extensive follow-up activities to be expected. Problem solving skill development includes the ability to reexamine past work to discover why a solution was incorrect, but this did not occur to a large extent in the e-mail activity. If daily or even bi-weekly communications had been incorporated into the e-mail activity, it would have helped both the preservice teachers and the elementary students. The preservice teachers could have provided feedback in a more timely fashion, the elementary students could have asked for help, and they could have solved the same problem over again based on the preservice teachers' feedback. Telecommunications activities have the potential of almost instantaneous transmittal of messages. Although communications would not need to occur quite this rapidly to provide a successful learning environment for both the preservice teachers and the elementary students, this e-mail activity demonstrated the limitations of infrequent communications.

The problematic interaction selections were focused on specific aspects of interactions that the preservice teachers felt they could improve. The largest category of responses dealt with the quality of the problems sent to the elementary children. The preservice teachers felt it was problematic when they sent items that were too easy or too difficult for their student groups. A related category was when the preservice teachers' responses to problems contained errors. The preservice teachers were concerned about the impact of their messages on the elementary students. They wanted to help the elementary students develop problem solving skills, even though it was not something they felt well-equipped to do–especially when the e-mail activity first began. When their own participation limited the success of the elementary students, they felt badly about what they had done. This demonstrated the capability of the telecommunications medium to provide preservice teachers with meaningful opportunities to develop teaching skills.

The other category of items mentioned by the preservice teachers as problematic was when the elementary children did not explain their problem solving process well. For several of the preservice teachers, the lack of a complete written process by the elementary students was the most problematic aspect of their involvement in the e-mail activity. They would rather have sent a problem that was too hard or too easy and have their student groups explain what they tried than to send them an appropriate problem that the elementary students did not explain well. The preservice teachers had more control over what they chose to send than they did in the responses sent by the elementary students: If the preservice teachers sent a problem that was not at an appropriate level, they could simply adjust the following week. If the students sent incomplete messages, there was not much that could be done by the preservice teacher except asking them to explain their problem solving process in their following response. It was difficult for the preservice teachers to formulate adequate feedback when they had to guess how the students solved the problem. It also made them feel powerless.

In constructivist-based environments, teachers and students can learn from each other. Unfortunately, the structure of this e-mail activity did not always facilitate that learning process. Future telecommunications activities linking preservice teachers and elementary students need to stress the communication process not only for the purpose of expressing mathematical understanding, but also for mutual participation.

There were several categories of items chosen by the preservice teachers as positive interactions. Items eliciting the most responses by the preservice teachers were those directly involving the messages of the elementary students. The top three types of selections noted the elementary students' inclusion of personal information in messages, a discussion of the complete reasoning processes in solving the problems, and messages where the students told their college friends that the problem was at a good level for them. The involvement with the elementary children was clearly important to the preservice teachers–their choice of a major demonstrated their interest in working with children. Their positive interaction selections showed that the e-mail activity was one that allowed them to develop rewarding relationships and connections with elementary students.

The comments made by the preservice teachers regarding their involvement with the elementary students revealed that limitations of the e-mail activity existed, such as poorly composed elementary student responses. On the other hand, the comments also showed how much the preservice teachers enjoyed their involvement with the elementary students and their appreciation of the opportunity to work in a problem solving environment. Benefits of participation outweighed the negative aspects of the activity.

The preservice teachers' perceptions of the e-mail activity as authentic

One of the elements of a constructivist classroom is the creation of authentic learning experiences for students. Because face-to-face contacts with children are absent from most telecommunications-based activities, it was not certain if the medium could provide authentic learning experiences for preservice teachers. The three categories defined by Myers (1993) were used to help gain an understanding of how authentic the preservice teachers felt the e-mail activity was.

The degree of realness or genuineness was one of the characteristics of authenticity examined in the study. The results were very promising. Of the six case study participants, one rated the e-mail activity as being more genuine than the field experience. Two others rated the activities as equally real. The practicum came out to be more positive overall in terms of its realness than the e-mail activity, but in comparison, the e-mail activity fared well. The preservice teachers claimed that the activity helped to prepare them to teach mathematics; it increased their comfort levels in dealing with the subject since they received experiences

working in the content area. They saw that they could impact *real* children, and this was an important aspect of the activity. Even though they did not get to see the elementary students they worked with, the fact that these future teachers were linked to actual kids was important to them.

It was clear, based on the interviews and other collected data, that activities did not necessary have to be face-to-face projects with children in order for them to be perceived as real by the preservice teachers. Certainly, face-to-face activities were more ideal to them than activities conducted through telecommunications technologies. However, any experiences that preservice teachers had dealing with elementary students in teaching contexts was believed to be beneficial to their professional development. Because e-mail activities can be constructed and facilitated with relative ease compared to field experiences, their contributions to teacher preparation programs can be immense.

A second item used to assess the degree of authenticity of the e-mail activity was whether the project was perceived as challenging, inspirational, or empowering, and if it encouraged the preservice teachers to take risks. There were differences in the perceptions of these items among the case study participants. It was agreed by all six of these women that the activity challenged them to select appropriate problems for their student groups. They were empowered to provide feedback to their student groups that would help the students develop better problem solving skills. In general, since the preservice teachers had control over the problems they sent, they sometimes felt more empowered in the e-mail activity than they did in their field experience. In the field experience, they were forced to follow the lessons and parameters suggested by the cooperating teachers.

The structure of the e-mail activity was one that encouraged the preservice teachers to take risks. They suggested that since they did not have to be responsible for discipline or for dealing with the children who did not understand the problem, they sent items that they would not have used in a face-to-face setting. This was an important advantage of the e-mail activity. The preservice teachers had little background in teaching mathematics prior to their enrollment in the mathematics teaching methods course. Although they wanted to learn how to teach the subject effectively, they felt that a practice environment, such as the e-mail project, was one where they could experiment without dealing with consequences. In this sense, the e-mail activity was

perceived as an exploratory environment–one where risk-taking was encouraged. This was a positive implication of the e-mail activity.

The third criteria of an authentic activity was that it should make a difference in the lives of the learner. Generally, most of the preservice teachers concurred that they learned several things as a result of their involvement. They learned about the skills of elementary students and about children of different age levels. They learned how important it was for students to effectively communicate the process they used in solving the problem. Beyond these generalities, the case study participants each shared aspects of the e-mail activity that made a difference for them. For example, Emily gained much confidence in herself regarding teaching mathematics, and Lori learned about her own problem solving process. Based on her responses toward the end of the e-mail activity, it was questionable whether Jessica felt that the activity made a big difference in her life. Overall, the field experience had a larger impact on the lives of the preservice teachers than did the e-mail activity. An important finding, however, was that the e-mail activity helped many of the preservice teachers in their professional development.

Considering Myers' three criteria, the e-mail activity was found to be moderately to highly authentic for each of the six case study participants. Since each of these preservice teachers had different abilities, expectations, and student groups, they all had different experiences as a result of their involvement. Some of the preservice teachers had a more positive experience than others. This showed that e-mail activities can be constructed to be authentic learning experiences for preservice teachers.

As revealing as Myers' criteria were regarding the participation of the preservice teachers, his theory did not completely address all of the factors that emerged with respect to the authenticity of the activity. One of the qualities of the activity that came up repeatedly during interviews with the six case study participants was the issue of control. Several of the preservice teachers felt very much in control over the activity; they could choose the problems to send and what they wanted to communicate to their student groups. Because they did not need to deal with discipline, they had more control over the content of what transpired than they would in a regular classroom. However, they were not present as the students solved the problems, and they had no control over how well the students wrote about their problem solving processes. The e-mail activity was a fairly rigidly

structured project, and yet the preservice teachers still felt in control over what transpired. Although Myers' criteria include empowering learners, his theory does not address the issue of control. It became clear during the research that an important element of an authentic activity is that the learner feels they have some control of the situation.

In addition, Myers' criteria are based completely on the learners' perception of the activity. It is possible for an activity to be constructed that learners find to be very authentic, and yet experts in the field could evaluate the activity much more negatively. There are elements of authenticity that should be evaluated by people other than the actual learners. In this e-mail activity, for example, the elementary students and the participating teachers may have had different perceptions of the activity as authentic than the preservice teachers held. In addition, the activity should also be evaluated to determine if it was really helping to prepare the preservice teachers to teach elementary mathematics. The preservice teachers could have rated the activity as being very highly authentic without learning the skills to prepare them to teach. Although the learners' perceptions of an activity are very important, authenticity should include the views of others as well.

The effect of mathematical anxiety levels on the preservice teachers' involvement in the e-mail activity

The feedback provided to the elementary students varied widely among the preservice teachers. In several instances, the preservice teachers were unable to use the information from the students' messages to compose responses that would help the elementary students develop their problem solving skills. The preservice teachers simply told the students whether their solution was right or wrong, and if wrong, explained a way to solve it. Other preservice teachers provided much more depth in their responses to student messages by carefully analyzing the students' processes. The largest factor contributing to the feedback provided to the elementary students was the preservice teachers' confidence in their mathematical ability. The preservice teachers with confidence in themselves were willing to analyze the work students produced in an effort to understand the processes used in solving the problems. Their feedback more explicitly reflected the processes used by the elementary students. The preservice teachers with higher levels of anxiety toward mathematics did not refer to specific processes, but instead wrote more impersonal messages to their groups. They were afraid of making errors in their interpretations of what the elementary students did. If the preservice teachers provided only

general feedback (whether the students solved the problem correctly), they could eliminate the possibility that they misinterpreted what the elementary students did in solving the problem. The difference between the reactions of the preservice teachers with high and low levels of anxiety with respect to their feedback closely paralleled the literature noting differences in classrooms among teachers with varying levels of mathematical anxiety (Brophy, 1991; Conrad & Tracy, 1992; Grouws, 1985; Silver, 1985). The preservice teachers with high levels of anxiety toward mathematics were more concerned with right answers than they were with skill development.

The level of anxiety toward mathematics affected the length of time it took for the preservice teachers to determine the skill levels of the elementary children. The preservice teachers with high levels of mathematical anxiety took more time before discovering the skill level of their elementary groups than their low anxiety level counterparts. The preservice teachers with low anxiety levels may have had a more clear perception of their students' probable skills prior to the start of the activity. Regardless, they needed only one or two weeks to determine the skills of their groups, where some of the preservice teachers with higher anxiety levels did not find this level until late in the activity. A key factor here, however, was that despite the differences in the amount of time it took to discover the skill level, both groups of preservice teachers were able to discover what their student groups could do. If the e-mail activity had been only a short-term activity, the preservice teachers with high anxiety levels may not have discovered what their students could solve, however. For preservice teachers with a high degree of mathematical anxiety, experiences, including those involving e-mail, need to be long enough in duration so that the preservice teachers can become comfortable enough in the environment to help the children learn more.

Although all six of the case study participants agreed that the e-mail activity challenged them to make appropriate problem selections for their student groups, the three case study participants with high anxiety toward mathematics perceived the challenge differently than the three with low anxiety levels. The three case study participants with low levels of anxiety indicated that they felt comfortable with the challenge involved in selecting problems–it was something they could do. They felt empowered to discover the level of their student groups and to help these children develop problem solving skills. The preservice teachers with high anxiety

levels were less confident in their abilities to address the needs of their student groups. They believed they would learn from their interactions, but they also believed that their own success was based more on their elementary students than it was on them. Instead of feeling empowered like the preservice teachers with low levels of mathematical anxiety, they instead felt challenged by the activity. This was likely to be true in many in-class activities and also in the practicum experience as well. The preservice teachers with high anxiety levels were generally less confident in themselves regarding mathematics, and they initially doubted whether they could effectively teach mathematics concepts to students.

There was progress made in the quality of problems sent during the e-mail activity, based on mathematical anxiety levels. Early on, the preservice teachers with high levels of mathematical anxiety sent problems that did not address the criteria suggested by the NCTM as well as preservice teachers with lower anxiety levels. By the end of the activity, there was virtually no difference in the quality of the problems by either of these groups. The preservice teachers with high levels of mathematical anxiety eventually learned about the skills of their student groups and were able to successfully adapt to these needs. They were also able to apply the criteria of a good problem to their selections. The e-mail activity was one where the preservice teachers could apply what they knew as they became more comfortable with their involvement. The lack of differences between the two groups demonstrated that activities can be constructed to address high anxiety levels.

The e-mail activity was one such project. In fact, it is possible that the e-mail activity provided time that would normally cut into classroom time for the preservice teachers with high anxiety levels to get comfortable with themselves as teachers of problem solving skills. The preservice teachers with high anxiety levels may leave the mathematics teaching methods class with teaching skills more similar to those of the preservice teachers with low anxiety levels because of this experience. The gaps in comfort and confidence were much larger at the beginning of the semester than at the end, signifying growth among the high anxiety participants. The e-mail activity forces the preservice teachers who have high anxiety levels to work with skills they may normally not choose to address in an elementary mathematics curriculum. Instead of working drill and practice exercises, as teachers with high anxiety levels often provide, they may be able to think back to the e-mail activity and consider more constructivist-based alternatives that better address the NCTM Standards.

Design issues with respect to telecommunications-based activities

As telecommunications activities become more and more prevalent in teacher preparation programs, it is necessary to look at qualities that can help make these activities more effective. Several items emerged from this study.

The e-mail activity provided the preservice teachers opportunities to learn how to use electronic communications in a meaningful way. It was more than simply an exercise in sending and receiving messages to them. Because the preservice teachers were paired with elementary children, their use of the technology had a purpose. Communicating with real children made the activity rewarding to them; after all, they chose to be teachers because they enjoyed working with kids. The role of the preservice teachers in the e-mail activity was to help these children develop mathematical problem solving skills. In doing so, they learned about the children and also about selecting appropriate problems based on the skills of the students and on what the NCTM suggested were quality problems. Because the preservice teachers had to continually adjust the problems they sent and the feedback they provided to the elementary students in this project, the activity remained strong throughout the ten-week communication period. Had the structure of the e-mail activity been less purposeful, it was likely that the preservice teachers would have perceived less value in their participation.

The success of the activity was based largely on the quality of the messages provided by the elementary students. Poorly written messages regarding the process used to solve the items made it difficult for the preservice teachers to develop an understanding of the students' ability levels. Because they could not work with the students in a face-to-face environment to clear up any questions, it was important that the elementary students be able to clearly explain their thoughts. In order for e-mail activities to be structured most effectively, the elementary student pairs need to be selected carefully. The e-mail activity provided an environment where the preservice teachers could learn from the elementary students, and the elementary students could also learn from the preservice teachers. The learning went only as far as the communication allowed, however. For this reason, links need to be established with practicing teachers exhibiting a commitment to the activity, so that they can assure quality responses from their students.

The once weekly communication pattern established in this particular e-mail activity was not ideal. The elementary students could not ask the preservice teachers questions that would clarify problems that were sent to them. The preservice teachers felt uncomfortable asking the elementary students to try a problem again after they got it wrong the first time because of the time lag between when they first sent the problem and when they were providing feedback on it. The communications aspect of the e-mail activity was very positive, but the preservice teachers wanted there to be more of it. Despite the fact that additional e-mail sessions would take more of their time, the preservice teachers felt that the gains from an increased number of messages would be worth the time investment. It may be more difficult to find elementary participants willing to devote even more time to the e-mail project. However, the rewards would likely be greater for both groups. 'As telecommunications technologies make their way into every elementary classroom, this may be less of a factor than it was in this study.

Although many of the college students felt that they learned about writing and/or selecting good problems for their students, it was a very difficult learning process for some of them. One of the college students who struggled all semester to come up with appropriate problems made a good suggestion. She said, "I think it would be a good idea, especially in the beginning, to share problems that were sent and discuss them [in the mathematics methods course]. Because I know the first few weeks I thought I was doing it right and I wasn't. So if I would have had my problem critiqued, I would have known what I was doing wrong." Although the preservice teachers were sending problems to students at several different grade and ability levels, small groups of preservice teachers could have discussed each other's problem choices and commented on not only appropriateness, but also wording, adaptability, and even follow-up possibilities. It could also have been a way for each of the preservice teachers to build up a collection of different problems to use in the future.

Overall the e-mail activity compared favorably to the field experience. Many of the preservice teachers were able enhance their skills in teaching children mathematical concepts through their participation in both activities. Neither of the activities alone were ideal for all of the preservice teachers. Together, however, more of the preservice teachers were able to learn in a mathematical teaching environment. So although a quality field experience was more highly desired by the preservice teachers, the e-mail activity served to enhance what they

learned through direct contact with children in classrooms. There was much merit in the use of e-mail activities for this purpose.

Overview

The results of this study suggested the possibility that electronic communications could add to the success of preservice teacher preparation programs. Although this particular activity was limited to mathematics, connections could be made with elementary or secondary students across all content areas in meaningful ways. The communications aspect provided through e-mail activities provides authentic links to groups of learners for the future teachers.

Suggestions for Further Research

Because the use of telecommunications in teacher preparation programs is relatively unexplored, there are still many areas that need considerable research. This study only addressed how preservice teachers reacted to one specific e-mail activity; there are certainly many different ways of using this technology as a vehicle to help prepare future teachers. It is important to address how electronic communications can be used *effectively* within teacher preparation programs. For example, it would be worthwhile to specifically examine whether the number of interactions influences the outcome of e-mail activities or the perception of these activities as authentic. It is possible that valuable links could be established not only between preservice teachers and elementary children, but also between preservice teachers and other preservice teachers or between preservice teachers and practicing teachers. Research could help determine the kinds of activities that could help the preservice teachers in their preparations.

The relationship between preservice teachers and elementary students in e-mail activities also has some interesting prospects to explore, especially with respect to preparing the college students to become teachers. It would be interesting to examine whether a *relationship* needs to be established or order for the preservice teachers to learn from the experience. For example, if the preservice teachers in this activity sent the same problem to students at ten different locations, they might have learned different things than they learned in this particular

activity. However, they may have learned less about what constitutes a good problem, and be less likely to adapt to specific needs of certain students.

Since this study indicated that the preservice teachers learned about the students and about helping to develop mathematical problem solving skills through their interactions, further explorations could be done to construct simulations and other computer environments that expand upon what the preservice teachers viewed as benefits of the activity, while decreasing some of the limitations. For example, the delayed response time could be decreased in a simulated environment. In order for this type of environment, computer-generated or otherwise, to be created, more studies such as this one need to be conducted to determine how preservice teachers react to different situations.

Studies have shown that there are differences in the teaching approaches used by teachers with high and low mathematical anxiety levels. If teacher preparation programs can address the needs of the college students who have high anxiety levels, it is possible that the differences in teaching approaches do not have to be as large. Continued research on possible techniques to address mathematical anxiety would be beneficial.

In addition to studies dealing with the reactions of preservice teachers, this particular research project also suggested areas of exploration regarding the way the elementary students react to similar projects. Researchers could explore whether electronic communications help to foster mathematical communication and reasoning in the same way that other activities provide. The elementary students' perceptions of various activities could be examined to determine the authenticity of the different projects.

Conclusions

The instructional use of computers has become a very important part of educational research. Originally, research in this area concentrated on examining the computer as a teaching tool, while more recent research has explored the role of the computer in learning. Most of the research has centered around the learning that takes place among elementary or secondary students. Preservice teachers are also learners, and the computer may facilitate their understanding as well. Telecommunications is one computer-based technology that has potential to assist them in their professional preparations.

This study focused on one specific e-mail activity and the preservice teachers' involvement in it over a ten week period. Five conclusions were drawn based on the data collected in this study:

1. E-mail activities can help preservice teachers in their development to teach mathematics to elementary children;
2. E-mail activities can be authentic learning experience for preservice teachers;
3. E-mail activities can help preservice teachers understand the importance of communicating mathematical understanding;
4. E-mail activities can help minimize the gap in performance between preservice teachers with high and low anxiety levels toward mathematics;
5. E-mail activities in the teacher education curriculum can help preservice teachers see telecommunications as a possible teaching and learning tool for their elementary students.

Although the preservice teachers did not work with children face-to-face in this e-mail activity, this learning opportunity still facilitated their growth as teachers. In the e-mail activity, the preservice teachers were linked with elementary children within a structured environment. Because the environment was structured, they could focus specifically on helping children develop mathematical problem solving skills. As the preservice teachers learned more about the elementary students, mathematical problem solving, and themselves, their growth was reflected in their messages to their student groups. There was enough flexibility in the e-mail activity for the preservice teachers to participate based on their comfort levels and zone of proximal development. Very importantly, the preservice teachers saw themselves as teachers as they communicated with their student groups.

Despite not seeing the elementary children they communicated with, the results of this study indicated that face-to-face activities were not a requirement for an activity to be considered authentic by the preservice teachers. The preservice teachers had control over what they sent to the elementary students. They sent problems that were comfortable to them. Their feedback was also based on the assistance they were ready to provide to the students. A constructivist approach suggests that not all learners will gain the same knowledge

from an experience. The e-mail activity allowed the preservice teachers to explore different aspects of teaching and learning within a problem solving framework.

Few of the preservice teachers had any experience with the NCTM's communications standard prior to enrolling in the course. They were not asked, as students, to expand upon their thinking the way the NCTM now encourages. Because they relied on the elementary students to write thorough descriptions of their problem solving processes, the preservice teachers grew to realize the importance of this skill. When the process was not explained thoroughly, the preservice teachers had difficulty providing feedback to the students that would help them grow as problem solvers. In order for preservice teachers to fully benefit from e-mail activities, participating teachers need to work with their elementary students to develop effective communications skills. A commitment to this skill development should be a consideration when selecting groups to work with.

Research documents differences in teaching styles between preservice teachers with high and low mathematical anxiety levels. Initially in the e-mail activity, some differences were found in performance of the preservice teachers based on their levels of mathematical anxiety. However, by the end of the e-mail activity, performance differences were very minimal. The preservice teachers with high levels of mathematical anxiety were able to grow and develop as teachers in this environment. The e-mail activity, along with a constructivist-based teaching approach in the teaching methods course and a field experience in a local elementary school, was a relatively non-threatening environment that helped the preservice teachers learn how to teach mathematical problem solving skills. The small number of differences found between the preservice teachers with high and low anxiety levels demonstrated the possible positive implication of similar activities.

One other conclusion was that the preservice teachers' involvement in the e-mail activity helped them to see the value of using telecommunications in their curriculum. They gained experience using the technology in a meaningful way. They saw a purpose and a value in using e-mail with their future students because of what they learned as a result of their participation.

The implications of this research indicate that telecommunications-based activities have a place in teacher preparation programs. The use of the technology to link future teachers with elementary children created a meaningful learning opportunity for the preservice teachers. Although links to elementary children using

technology were not as positive as face-to-face work with students in a classroom setting, it was shown that these links were valued, authentic, and meaningful opportunities. As more and more elementary classrooms acquire Internet connections, links between these students and preservice teachers will continue to provide meaningful opportunities for both groups of learners. Teacher training programs would greatly benefit from tapping into this resource.

APPENDIX A. MATHEMATICS ANXIETY RATING SCALE

APPENDIX B. THE PROBLEM SET

Problem Set

Last 4 SS# _____

Please rate the following items based on their appropriateness as non-routine math problems to send to your elementary student groups through e-mail. It is not necessary to solve the problems. Then, under each item, explain briefly why you gave it the rating that you did.

Use a scale where a 1 would indicate that the item is not an appropriate problem and definitely should not be used, and a 5 would indicate that the item is very appropriate and should definitely be used in the e-mail activity.

1. You have the task of painting your classroom walls. Each can of paint can cover an area that is 200 square feet. How many cans will you need? 1 2 3 4 5

2. The tens digit is two less than the ones digit. The difference between the ones digit and the hundreds digit is the same as the tens digit. The sum of all of the digits is equal to three times the ones digit. What is the number? 1 2 3 4 5

3. Bill and Sue went shopping for a birthday present for their mother. They first bought earrings for $7.95. Then they bought her some perfume for $3.52. They also bought her a picture frame for $5.37. How much was their total? 1 2 3 4 5

4 What are the next 4 digits in the following pattern? 3 7 1 1 1 5 1 9 2 3 1 2 3 4 5

5. You are going on a trip with your parents and they have asked you to help them figure out how much money they will need to set aside for fuel. They are allowing you to choose a city in any state other than your own for the vacation. How much money will they need? 1 2 3 4 5

6. On a test, I had 7 times as many correct answers as incorrect answers. There were 120 items on the test. How many items did I get correct? 1 2 3 4 5

7. Fred, Walter, and Duc live next to each other. They are a teacher, a medical doctor, and a salesperson. Walter lives in the middle house. When Duc went on a vacation, the medical doctor kept his dog. The teacher and Fred share a fence. What work does each person do? 1 2 3 4 5

8. How many times does your heart beat in a year? 1 2 3 4 5

9. Bob worked twice as long as Dan. Dan worked one hour more than Jim. Jim worked 2 hours less than Pedro. Pedro worked three hours. How many hours did Bob work? 1 2 3 4 5

10. There are 8 teams in a basketball league. Each team plays each of the other teams twice. How many total games are played? 1 2 3 4 5

APPENDIX C. SAMPLE INTERVIEW QUESTIONS

Interview #1

1. You were asked to complete a measure of math anxiety. The results showed that you had high/low math anxiety. Do you think this is an accurate reflection? Why or why not?

2. What math courses did you have in high school and college (get from anxiety test)

3. Why did you decide to become a teacher?

4. (Show the Problem Set that the respondent completed). Based on the definition provided on the sheet, can you make up a question that would definitely not meet the criteria for being a problem?

5. How do you know if an item is too hard or too easy for the age level?

6. How long do you think is a reasonable time for student to try working on a problem?

7. Should elementary students be allowed to use calculators on problems of this type? Why or why not?

8. Of the items on the Problem Set, which ones do you think have content that is of interest to students and why?

9. You wrote about the math abilities you think your elementary student groups have. Why do you think they have these skilis?

10. Do you think you will be able to send appropriate problems to your student groups? What do you think will be your biggest challenges in doing this?

11. How will you know if they are appropriate?

12. What is your initial feeling about this whole activity?

13. How do you think the elementary student groups will view you in the e-mail activity?

14. What will the practicum kids see as your role?

15. What are the similarities between the practicum and the e-mail activity?

16. What are the differences?

Interview Two:

1. Can you think of anything to comment on based on our last interview? Additions, changes?
2. How appropriate do you think your problems have been? Ability levels, interest, consistent with teacher expectations for a problem. Are there inconsistencies with what we've discussed in class?
3. What is your impression of your elementary student groups?
4. Has your impression of the capabilities of your groups changed at all?
5. So far you have sent three problems. Where did you find them?--take out problems & write
6. Does anything stick out in your mind about any of the interactions so far?
7. Have there been any problematic areas so far?
8. What are the things you think are going well?
9. I rated your last problem. What is your impression of this rating?
10. Do you have any anxiety about the e-mail activity?
11. How do you feel about the e-mail activity now that we've done it for a few weeks?
12. What are your strengths in the e-mail activity?
13. What are your weaknesses in the e-mail activity?
14. What is your expected role in your practicum?
15. Do you feel any anxiety about the practicum?
16. What causes anxiety for you in teaching situations?
17. For the age level of your practicum, what are the most important math skills?
18. What do you think will be the importance or role of problem solving in your math curriculum?
19. Would you consider yourself a constructivist or behaviorist and why?

Interview Three

1. Does anything come to mind about any of the most recent interactions? Anything good/bad/ unusual?

2. Where did you find the new problems since last time?
specified on printed interactions sheets

3. Have you changed your approach to problem selection?

4. Tell me what you know about your students.

5. Tell me what you know about the mathematical or problem solving skills of your students.

6. Let's look at the interaction you selected to send me as your choice for being problematic. Tell me more about this choice. How did it make you feel?

7. Do you think the elementary students viewed it as problematic?

8. What have your done since then to create less problematic situations?

9. Let's look at the problem you selected to send me as your choice for being a positive interaction. Tell me about this choice. How did it make you feel?

10. Do you think the elementary students viewed it the same way that you did?

11. Let's say there was a continuum of "realness" or "genuineness". Where along this continuum of "genuineness" would you put this e-mail activity? Does it seem like a real activity or does it seem like something you have to do to satisfy the requirements of the course?

12. In terms of "realness" or "genuineness" how does the e-mail activity compare to the practicum?

13. Do you feel as if you have taken any risks in this activity?

14. We all have beliefs about ourselves, what we can and can't do. Has the e-mail activity in any way challenged you with respect to any personal limitations?

15. Are there things that you've tried/said/done in this activity that you wouldn't have done in a regular classroom situation?

16. Compare the relationship with your e-mail groups as opposed to your practicum students.

17. Tell me about your practicum experience so far.

18. Explain how your practicum students would react to the problems that you've been sending to your e-mail groups.

Interview Four

1. Rate the practicum if they did not do that in interview 3.
2. Write down sources of problems sent since last interview.
3. Since we've done the e-mail activity for 10 weeks, what kinds of math skills do you now think your students have?
4. Do you think these students are typical for kids in these grade levels? Why or why not?
5. What are aspects of the practicum that the e-mail activity does not provide?
6. What are aspects of the e-mail activity that the practicum does not provide?
7. Expand upon your written reflection regarding the e-mail activity.
8. What have you learned as a result of your practicum experience?
9. What have you learned as a result of the e-mail activity?
10. How could the e-mail activity be set up to better help to prepare preservice teachers--think widely. It doesn't have to be limited to math or the kind of structure that we had in this activity.
11. What are things that should be addressed in the math methods course that were not covered this semester?
12. What is your comfort level in mathematics as far as teaching it goes?
13. What do you feel will be your strengths with respect to teaching math?
14. What do you feel will be your weaknesses with respect to teaching math?
15. Where will you be next semester? During Break?
16. What name would you like to represent you?

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